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USSR Report

LIFE SCIENCES

BIOMEDICAL AND BEHAVIORAL SCIENCES

(FOUO 4/82)

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CONTENTS

APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000500080012-5

ARTIFICIAL INTELLIGENCE

UDC: 621.391.19

OBJECT DESCRIPTION AND RECOGNITION IN ARTIFICIAL INTELLIGENCE SYSTEMS

Moscow OPISANIYE I RASPOZNAVANIYE OB"YEKTOV V SISTEMAKH ISKUSSTVENNOGO INTELLEKTA in Russian 1980 (signed to press 30 Jun 80) pp 2-4, 134

[Annotation, foreword and table of contents from book "Description and Recognition of Objects in Artificial Intelligence Systems", edited by V. S. Gurfinkel', doctor of medical sciences, and V. S. Fayn, candidate of engineering sciences, Institute of Information Transmitting Problems, USSR Academy of Sciences, Izdatel'stvo "Nauka", 2300 copies, 137 pages]

[Text] This collection consists of articles dealing with the following three problems: mathematical modeling of variability of objects that are of practical interest (speech process, some types of images, etc.), use of mathematical methods in medicine and some aspects of voice control of computers in man-machine systems. It is intended for specialists in the field of artificial intelligence, pattern recognition and allied fields.

Foreword

Time has made appreciable corrections in interpretation of the problem of image recognition, understanding of its substance and place in modern scientific engineering knowledge.

One of the main manifestations of this development is the increasingly clear realization that the problem of recognition proper is, in a certain sense, secondary to another problem, that of demonstrating and describing the essence of variability of the object to be identified. In all three cases where the essence of variability is well-studied, organization on its basis of an identification process is now a rather well-studied matter. Construction of a description of variability is also of value independent of recognition, since it opens the way for solving another problem in the field of artificial intelligence, that of artificial generation of changes in an object (design, verbal synthesis, automatic multiplication, etc.). All this has resulted in publication of many works in recent years that deal with mathematical modeling of the patterns upon which a certain variable phenomenon or object is based. This tendency has also been manifested in this collection: the articles by Ye. F. Yurkov and V. S. Nagornov, A. S. Omel'chenko and V. S. Fayn, Ye. P. Ponomarev and Yu. N. Prokhorov, V. N.

Sorokin, A. P. Vaynshtok deal with the search for descriptions of the patterns characterizing object variability in diverse problems of practical importance.

Unfortunatley, demonstration of the essence of variability or its relation to externally observed characteristics of an object is a very difficult problem, and to this day it is not always solvable. A classical example is referable to the problem of seismic forecasting or zoning. Medical diagnostic problems, which are also extremely difficult, are just as important. However, the urgent need to solve them is a powerful stimulus for constantly applying more and more efforts. In this collection, the articles of A. M. Alekseyevskaya and V. S. Pereverzev-Orlov, P. Ye. Kunin and V. P. Karp, Yu. B. Fogel'son deal with these problems.

Another problem of artificial intelligence touched upon in this collection is referable to organization of dialogue in a man-machine system. Making the machine capable of understanding vocal commands is one of the means of satisfying the requirement of maximum convenience and naturalness of man's function in such a system. Research, which has been pursued in this direction for several years, is the topic of articles by S. N. Krinov, V. P. Savel'yev, G. I. Tsemel', as well as A. V. Vasil'yev, S. S. Raksheyev and V. M. Chizhkov, and S. M. Shevenko.

No doubt specialists in the field of pattern recognition and forecasting will be interested in the originality of the proposed methods and timeliness of topics discussed.

Contents

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CSO: 1840/161

BIOCHEMISTRY

UDC: 539.612

VAN DER WAALS FORCES OF INTERACTION BETWEEN SPHERICAL AEROSOL PARTICLES AND CYLINDRICAL FIBER AS PARTICLES APPROACH THE FIBER

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 260, No 5, Oct 81
(manuscript received 8 May 81) pp 1189-1191

[Article by I. Tashpolotov, B. F. Sadovskiy and Zh. T. Tekenov, Physicochemical Scientific Research Institute imeni L. Ya. Karpov, Moscow]

[Text] It was demonstrated in a paper [1] dealing with aerosol filtration theory that Van der Waals forces may play a considerable part in deposition of aerosols on filter fibers. On the other hand, it is necessary to know the force of interaction of aerosol particles with cylindrical fibers in order to run processes of regeneration of various fibrous filters. The forces of interaction of these solids are discussed in [1, 2], without consideration of electromagnetic lag. However, in the course of deposition of aerosol particles on the surfaces of filter fibers, interaction forces also play an appreciable role at distances in excess of 0.1 μm. In this case, the hypothesis advanced by London, to the effect that each atom instantly reacts to the fluctuating electric field of another atom, cannot be considered, strictly speaking, correct, as was demonstrated by Casimir and Polder [3]. According to [3], at distances in excess of 0.1 μm, interaction energy is determined by the law of $1/r^7$. Interaction of molecular forces between a spherical particle and a cylindrical fiber had not been previously examined with consideration of the lag effect.

According to the results in [3], the energy of interaction between two condensed bodies (sphere and cylinder) can be expressed as the integral of attraction energy:

$$E = -\int_{V_1}\int_{V_2} \frac{n_i n_j K_{ij}}{r^7}\, dV_1 dV_2, \qquad (1)$$

where V_1 and V_2 are the full volumes of the sphere and cylinder; n_i and n_j are the number of atoms per cm^3 of these bodies; K_{ij} is London's constant; r is the distance between centers of dV_1 and dV_2. The adequacy of such an approach was discussed in [4, 5].

Let us transform integral (1) into the following form:

$$E = -\frac{B}{\pi^2}\int_{V_1}\int_{V_2}\frac{dV_1 dV_2}{r^7}, \qquad (2)$$

where $B = \pi^2 \sum_i \sum_j n_i n_j K_{ij}$.

1. Let us consider integral (2). By integrating respectively in the cylindrical and spherical systems of coordinates for elementary volumes dV_1 and dV_2, with consideration of the integration limits (see Figure 1), we shall obtain:

$$E = -\frac{4B}{\pi D}\int_{D-R_1}^{D+R_1}\int_{R-R_2}^{R+R_2}\frac{1}{R}\left[R_1^2 - (D-R)^2\right]\frac{1}{r^5}\left(\frac{l}{S} - \frac{2}{3}\frac{l^3}{S^3} + \frac{1}{5}\frac{l^5}{S^5}\right)\times \qquad (3)$$

$$\times \arccos\frac{R^2 + r^2 - R_2^2}{2Rr}\, dR\, dr,$$

where $S = \sqrt{r^2 + l^2}$.

Integral (3) is not integrated in elementary functions. Calculation thereof is made by numerical methods.

However, if $l \to \infty$,, after making simple calculations, from (3) we shall obtain the value of energy of interaction between the sphere and an infinitely long cylinder, with consideration of the molecular force lag effect:

$$E = \frac{16 B R_2^2}{15 D}\left\{\frac{4R_2^2 - 4D^2 - 7DR_1 - 3R_1^2}{12\left[R_2^2 - (D+R_1)^2\right]^2} + \right.$$

$$+ \frac{D^2 + DR_1 - 4R_2^2}{8R_2^2\left[R_2^2 - (D+R_1)^2\right]} - \frac{4R_2^2 - 4D^2 + 7DR_1 - 3R_1^2}{12\left[R_2^2 - (D-R_1)^2\right]^2} \qquad (4)$$

$$\left. - \frac{D^2 - DR_1 - 4R_2^2}{8R_2^2\left[R_2^2 - (D-R_1)^2\right]} + \frac{D}{16R_2^3}\ln\frac{D^2 - (R_1+R_2)^2}{D^2 - (R_1-R_2)^2}\right\}.$$

2. In order to assess the obtained equations, let us assume that R_1 and $R_2 \gg H$ (Figure 1). Then formula (4) can be approximated for energy of interaction between the bodies in question as follows:

$$E = \frac{B}{45H^2}\cdot\frac{R_1 R_2}{R_1 + R_2} \quad \text{or} \quad E = \frac{BR_c}{45H^2}, \quad \text{if } R_2 \to \infty,$$

where $R_1 = R_c$ is the radius of the sphere. (5)

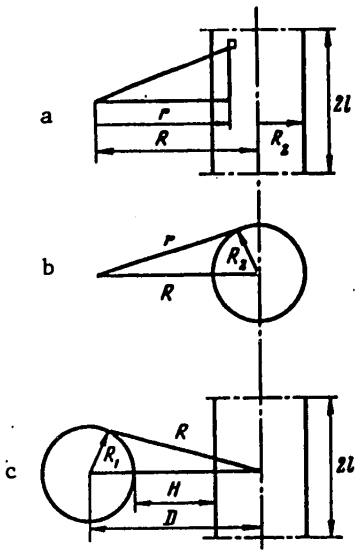

Figure 1.
Diagram of interaction between spherical aerosol particle and cylindrical fiber

For interaction force with consideration of (5) we shall have:

$$F = \frac{2BR_c}{45H^2}. \qquad (6)$$

On the other hand, the force of molecular attraction between a sphere and flat surface should, according to Deryagin [6], be proportionate to sphere R_c radius:

$$F = 2\pi R_c E(H), \qquad (7)$$

where E(H) is the energy of interaction between two infinite plates per cm^2. This energy according to Lifshits [7] is determined by the formula:

$$E = \frac{hc}{3H^3}\,\frac{\pi^2}{240}\left(\frac{\epsilon_0 - 1}{\epsilon_0 + 1}\right)\varphi(\epsilon_0). \qquad (8)$$

where h and c have the usual meaning, ε_0 is the electrostatic dielectric constant and $\phi(\varepsilon_0)$ is a function whose value is determined from a graph.

From (7) and (8) with known physical parameters of a quartz lens ($\varepsilon_0 = 3.6$; $R_c = 26$ cm [6]), for the force of interaction between the lens and a flat surface we can obtain:

$$F \cong 7{,}19 \cdot 10^{-18} \cdot H^{-3}. \qquad (9)$$

From formula (6), taking the value of constant B for quartz from [6], we get:

$$F \cong 3{,}47 \cdot 10^{-18} \cdot H^{-3}. \qquad (10)$$

Thus, the force of interaction between a sphere and flat surface calculated with formula (6) is about one-half the force as determined with formula (7). In order to obtain a more precise value we must take into consideration the other terms contained in (4).

3. According to [1], the condition for complete deposition of particles from the zone of molecular attraction has the following appearance:

$$u < \frac{pF}{6\pi\eta R_1 H}, \qquad (11)$$

where u is the velocity of the particle in the zone of attraction, p is the length of filtering surface along current line and η is gas viscosity.

Let us consider the following instance: the radius of a gold particle $R_1 = 10^{-4}$ cm, the radius of glass fibers $R_2 = 10^{-4}$ cm, $p = 5 \cdot 10^{-2}$ cm, $B = 2.3 \cdot 10^{-19}$ erg·cm, $H = 10^{-4}$ cm, then we shall have, from condition (11), $u < 5.7$ m/s, having found F from formula (4).

If u is velocity of air (gas) in the boundary layer formed around cylindrical fibers, knowing the structure of the laminary boundary layer [8] we can calculate for our case the velocity of free-stream [incident] flow u_∞ using the following formula:

$$u_\infty = \sqrt[3]{25\nu \frac{u^2 \alpha R_2}{H^2}}, \qquad (12)$$

where ν is kinematic viscosity of gas and α is the angle measured from the frontal critical point of the cylinder to the point where the particle settles.

The velocity of incident flow u_∞ for an angle $\alpha = \pi/6$, calculated using formula (12), has the following value: $u_\infty < 18.5$ m/s.

Thus, with filtration of aerosol particles at the rate of $u_\infty < 18.5$ m/s, there is deposition of particles upon nonbumping collision at a distance of 1 μm from the surface of the fiber due to Van der Waals forces. To determine conditions for deposition of non-spherical particles, one must take into consideration the coefficient of sphericity.

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NONLINEAR INFORMATION CHANNELS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 262, No 3, Jan 82 (manuscript received 25 Jun 81) pp 554-555

[Article by N. N. Yevtikhiyev, corresponding member of the USSR Academy of Sciences, and M. A. Savchenko, Moscow Institute of Radio Engineering, Electronics and Automation]

Text] Theory of nonlinear information channels with scintillation [flicker] was expounded in [1]. The main idea of this theory was that when the channel operates at a high noise level there is very marked increase in fluctuation of parameters of transmitted signal, such as amplitude and frequency. Then the signal can be described as effective temperature T_s and noise level as the corresponding temperature T_n. With $T_s = T_n$, the channel's capacity will be zero, which means that signal amplitude at the output in the receiver equals zero.

This situation can be interpreted as a phase transition. But then, the operating mode of the nonlinear channel in the temperature range of $T_s > T_n$ should be described by a parameter of order, S_0 (in this case, this is signal amplitude at the output) just as is done in phase transition theory [1]. When $T_s > T_n$, the parameter of order will be $S_0 = 0$ and with $T_s < T_n$ $S_0 \neq 0$. We can then write down the free energy of the system in the temperature range of $T_n > T_s$. In phase transition theory such a state is called paramagnetic.

Thus, the expression for free energy can be written as follows:

$$F = \tfrac{1}{2}\tau S_0^2 + \Gamma(T)S_0^4 + \Delta(T)S_0^6 + \ldots, \qquad (1)$$

where $\tau = 1 - T_s/T$, $\Gamma(T)$, $\Delta(T)$ are slowly changing positively defined functions of noise temperature. From the minimum thermodynamic potential $\partial F/\partial S_0 = 0$, we can calculate function $S_0(T)$ in the vicinity of the phase transition points and then, using temperature derivatives, the entropy and heat capacity of the signal, which enables us to determine the channel's capacity.

As we mentioned above, there is increase in fluctuations of parameter of order in the vicinity of the phase transition point, as well as in their typical dimension

$$\xi \sim \tau^{-\nu} \quad (\nu > 0),$$

i.e., with $\tau \to 0$, $\xi \to \infty$. Then Γ is a function of variable x (in the simplest case, $x = -\ln \tau$) and satisfies the nonlinear differential equation of Lie:

$$-\Gamma' = \Psi(\Gamma), \tag{2}$$

where $\Psi(\Gamma)$ is called a (Hell-Mann-Low) function

$$\Psi(\Gamma) = A\Gamma^2 + B\Gamma^3 + C\Gamma^4 + \ldots, \tag{3}$$

A, B and C are coefficients of expansion.

If the system is not characterized by one parameter of order, but several--$S_{0}i$, ..., $S_{0}k$, ... $S_{0}p$--a set of values Γ_i appears with fourth-order terms. Consequently, a system of nonlinear differential equations appears, i.e., the problem of phase transition amounts to a problem of theory of nonlinear fluctuations. Solving the equations enables us to determine the nature of phase transition in the system. It can be either continuous (second class, i.e., parameter of order S_0^2 is not continuous at the phase transition point) or in steps (first class).

If an electromagnetic information channel is being considered, S_0^2 is the amplitude of electric and magnetic field in the wave, $S_0^2 = E^2 + H^2$; if it is a biopolymer channel, S_0^2 is the amplitude of the elastic wave.

Biophysical communication channel: If a biopolymer communication channel is being considered, there can be interferences in it due to the effects of high-frequency electromagnetic radiation. Tuning out the noise involves an increase in signal energy, i.e., its input amplitude. If there is a stepped phase transition in the system, it is related to softening of the coherent phonon mode of the polymer chain [2, 3]. But then we are in the region of the spectrum, in which linked phonon states--solitons--can arise, i.e., tuning out from the interference leads to a change in channel operating mode with insignificant change in input power. Now the signal can be transmitted in the form of solitons [4], which are resistant to the effects of a high-frequency electromagnetic field. Thus, we are able to change the nonlinear channel to a different, more stable operating mode.

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INTRODUCTION TO ELECTROECOLOGY

Moscow VVEDENIYE V ELEKTROEKOLOGIYU in Russian 1982 (signed to press 7 Jan 82) pp 2-7, 335-336

[Annotation, foreword by Academician V. Ye. Sokolov, introduction and table of contents from book "Introduction to Electroecology" by Vladimir Rustamovich Protasov, Anatoliy Ignat'yevich Bondarchuk and Vladimir Mendelevich Ol'shanskiy, Institute of Evolutionary Morphology and Ecology of Animals imeni A. N. Severtsov, USSR Academy of Sciences, Izdatel'stvo "Nauka", 1800 copies, 336 pages]

[Text] This monograph outlines the range of problems in a new direction, electroecology--the science dealing with electric correlations in living nature--on the example of fish, which are animals with high electric sensibility and capacity to generate electric fields. The following are discussed in this work: history of the question, status of the problem, analytical methods of evaluating electric fields of biological objects, questions of building the physicomathematical apparatus adequate for problems of electroecology, and it also evaluates the effects and aftereffects of natural and artificial electric fields on ichthyofauna. The book is intended for a wide range of specialists--ecologists, ichthyologists, cyberneticists, bionic engineers and workers in the field of environmental protection.

Foreword

The book, "Introduction Into Electroecology," is an original piece of research. The authors did not limit themselves to a description of the existing situation in this young branch of ecology, rather, they devoted much attention to development of adequate physicobiological approaches to the problem. Although the entire study is referable to ichthyology and was conducted on the class of fish, the interaction models proposed by the authors could extend to other classes of animals with further development of ecology.

Not only is there discussion of electric interactions between fish and between fish and the geophysical environment, but emphasis is laid on questions of possible effects on fish of electromagnetic sources of anthropogenic origin.

Of course, not all of the issues are presented equally well, and this is in part attributable to the existing situation in the scientific literature. At

the same time, the significant amount of physicomathematical lay-outs appears logical for this branch of ecology in view of the complex nature of the problem.

This book will be of definite interest to a wide circle of biologists and technical specialists concerned with problems of environmental protection.

Introduction

Among the intensively developing branches of biology, in addition to genetics and molecular biology, we can mention ecology, the science dealing with the way of life of plants, animals and man. In our days, this discipline is undergoing a sort of rebirth. This is related, on the one hand, to technological progress, with which different forms of human endeavor become ecological factors; on the other hand, it is related to appearance of new methods of studying intrapopulation relations as a result of development of allied branches of science. For this reason, the newly arising problems and approaches to their solution form a new branch of ecology. The appearance of chemical ecology (see book by M. Barbier, "Introduction to Chemical Ecology," Mir, 1978) is attributable to expressly these circumstances.

It became possible for new branches of ecology to appear only as the result of interaction between ecologists and specialists in allied disciplines. Electroecology, an introduction to which is discussed in this monograph, is no exception to the foregoing. Electroecology is a young and very important branch of ecology. Electricity as an ecological factor is of interest, not only because of the enormous quantity of electric fields of anthropogenic origin, but their involvement in orientation and communication of some fish. The uniqueness of electric perception inherent in these fish has inspired scientists in different specialties to learn all about it.

When one speaks of electroperception, one occasionally uses the words, "they see": "fish see the world by means of a new sense" (see, for example, T. H. Bullock, 1973, 1974). And, although electric perception of fish is closer, let us say, to acoustic perception than it is to visual perception with regard to a number of features (morphology of receptors, distribution of receptors, frequency range, informativeness, etc.), use of the word, "see," appears to be quite natural. At the same time, we cannot fail to note that there is a substantial difference in ability of researchers to study vision and to study electric perception, a difference that refers not so much to the fact that the principles of construction of these receptor systems are different (Bullock, 1973), as to the fact that the researcher (man) does not have personal experience in electroperception and cannot directly (i.e., without the help of instruments) monitor a spontaneous or experimental situation. No matter how great the differences between human and animal vision, in most cases we are able to see the signs that have appreciable ecological significance to animals, for example, geographic and time-related distinctions of the background, coloration and changes (mating, seasonal) in coloration of animals and plants, bioluminescence, etc. Qualitative comparisons of human and animal visual skills (sharp-sighted eagle, blind mole, night vision of the horned owl) were made long before determination of the physical nature of light, before studies of physiology of vision, long before development of special instruments.

But when we try to assess the ecological significance of low-frequency electric systems of fish, we have not experienced such direct perception and we are compelled to proceed solely from accumulated theoretical conceptions and experimental data, and conducting experiments usually requires rather complex equipment.

With such a situation, we need not be surprised at the abundance of physico-mathematical calculations and physical models, or the profusion of technical terms inherent in the literature on the topic of "Investigation of the Role of Electric Fields in the Life of Fish." A number of technical ideas were discussed in biological literature much earlier than in technical literature proper. For example, the idea of active electrolocation and physical model corresponding to this idea were published in the JOURNAL OF EXPERIMENTAL BIOLOGY in 1958 (Lissman, Machin), whereas one of the first patents for electric location was issued in the United States to (V. Shvan) only in 1971, with priority as of 23 January 1967 (U.S. Patent No 3562633 class 324-1), i.e., almost 10 years later.

The book, "Introduction Into Electroecology," was written with reference to fish, which are animals with exceptionally high electric sensibility that use their bioelectric fields in ecology.

However, the scientific importance of the results of studying electroecological relations, which were pursued on fish, is not limited to this class of animals. In recent times, there has been increasingly frequent discussion in the scientific literature of the possibility that various animals use electromagnetic fields in ecology (see, for example, the book by A. S. Pressman, "Electromagnetic Fields and Living Nature," Nauka, 1964; Yu. A. Kholodov, "Man in the Magnetic Web," Znaniye, 1975). On the basis of the hypotheses of these authors which, unfortunately have as yet had little experimental validation, one can consider electroecology in a broader aspect, as a branch of biology concerned with various types of electromagnetic correlations. In this case, there is validity to consideration of electromagnetic interactions between different animals and plants, in the first place; in the second place, it becomes necessary to study the effects of the electromagnetic background of the environment on ontogenesis and, in the third place, to study some physiological functions with the use of electromagnetic fields (EMF) on the cellular, organismic or population levels. In this respect, the mathematical approaches developed for fish can also be used for other classes of animals.

At the same time, electroecology is faced with ichthyological problems. Perhaps electric ecology will be one of the keys that will enable us to comprehend such complex problems as homing, interspecific and intraspecific coordination of fish.

This book is only an introduction to the problem, but aside from the broad spectrum of examples of electric interaction of fish, it devotes much attention to attempts at quantitative analysis, engineering estimates of electric fields, interaction between specimens via this communication channel.

The engineering estimates, construction of models and quantitative estimates conform to the modern requirements of science and enable us to understand

the principles involved in the fucntion of some ecological systems. Thus, the problem of electric ecology is discussed from different points of view in this book. For this reason, it addresses itself to a wide circle of specialists--ecologists, ichthyologists, cyberneticists and bionic engineers--who will find here the history of the question and can assess the status of the problem, as well as extract the mathematics involved in evaluating the adjacent zones of electric fields and consider the influence of electric fields of surrounding background on the ichthyofauna.

This monograph was written by a team of authors: Introduction, Chapter 1 (History of the Problem) and Chapter 2 (Status of the Problem) by V. R. Protasov, doctor of biological sciences; Chapter 3 (Construction and Methods of Estimating the Mathematical System [Software?] Consistent With the Tasks of Electroecology) by A. I. Bondarchuk, candidate of engineering sciences; Chapter 4 (Bionic Assessment of Electrocommunication Systems of Fish) by V. M. Ol'shanskiy, junior scientist, and Chapter 5 (Assessment of Effects on Ichthyofauna of Electric Fields of Abiotic Origin) by V. R. Protasov and V. M. Ol'shanskiy.

Contents

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UDC: 62-501.7:574.6

STRUCTURE OF ALGORITHM FOR ESTIMATING STIMULI IN INSTANTANEOUS PERCEPTION

Moscow AVTOMATIKA I TELEMEKHANIKA in Russian No 4, Apr 82 (manuscript received 20 Jan 81) pp 50-53

[Article by L. M. Shcherbanskiy (Kurgan)]

[Text] Two variants of units are discussed, which reproduce an algorithm for estimating the number of stimuli perceived instantaneously. These devices have sensors, a set of random delays and multi-input OR logic circuit. Determination is made of probabilistic characteristics of reliability of estimating the number of delivered stimuli, and operating speed of the units is evaluated. It is maintained that the algorithm run in these units has features that are similar to the main characteristics of biological sensory systems.

The study of sensory systems raises the question of simulating instantaneous perception. It is known that man can estimate with high reliability a small number of elements of images (for example, points or spots) presented for a short period of time [1].

As the number of stimuli is increased (over 6-7) reliability of estimation diminishes. Analogous properties have been demonstrated in the cutaneous analyzer, auditory analyzer and others. It can be assumed that the properties of the same algorithm are the basis for similarity of properties of these analyzers. Simulation of this algorithm is of interest to both physiologists and engineers.

Analysis of the process of instantaneous perception enables us to advance the following hypotheses concerning the properties of the algorithm for estimating the number of stimuli.

In the first place, this algorithm is unrelated to scanning of outputs of all fibers of an afferent nerve. At least 10^3 s would be required to scan an entire nerve for estimating the number of delivered stimuli, the interrogation time constituting on the order of 10^{-3}s per fiber and there being on the order of $1 \cdot 10^6$ fibers in the optic nerve. The visual analyzer estimates the number of delivered stimuli in tenths of a second, consequently, most of the processing of information about number of stimuli occurs simultaneously (in parallel).

In the second place, the algorithm in question is stochastic, since in estimating the number of stimuli (for example, white [light] dots) the analyzer gives an undetermined answer, and with increase in number of stimuli the probability of correct estimation diminishes.

Let us consider two types of units that run the algorithm that can serve as a model of an unknown algorithm that exists in biological analyzers. Both units are based on the use of a principle known in engineering of transforming a set of simultaneously (in parallel) delivered signals into a sequence of signals. Figure 1 illustrates the flowchart of such a unit.

The analyzed complex signal, which contains several stimuli, is fed to the sensor field. Each sensor S simulates in this case the functions of a receptive field [2, 3]. The general requirement is that the sensor must react to different values of the stimulus in a binary code. For this, the sensor must contain a specialized input converter and threshold element. The specialized input converter transforms the stimulus into an analogue. In simulating, for example, the visual analyzer, photoelectric pickups (photoresistors, photodiodes) can serve as such a converter.

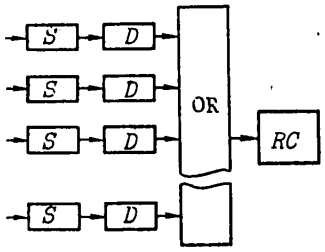

Figure 1.

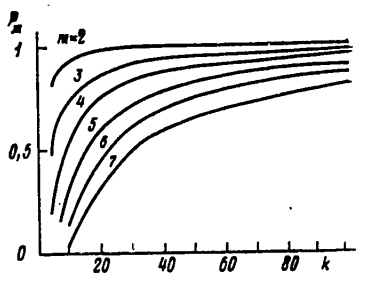

Figure 2.

It is further assumed that each stimulus activates only one sensor. The case where each stimulus (for example, a light spot) activates a group of receptive fields can be examined within the limits of the proposed algorithm, but is not discussed in this article. Sensors S that form the sensor field are connected to delay components D. The outputs of all delay components are connected to the inputs of the OR circuit. A recording counter RC for the number of signals is connected to the output of the OR circuit. Nerve fibers can be considered an analogue of delay components, whereas the functions of the OR circuit and recording counter are presumably performed on higher levels of the nervous system.

In analyzing the first variant of the unit, we shall consider that lag time τ, provided by each component is a discrete random value. Let us assume that the values of all delays are in the $[\tau_1, \tau_2]$ range and that in this range there are k possible discrete values--gradations of lag time.

Let us examine the operating cycle of this unit. A limited number of stimuli is delivered to the sensor field within a short time (exposure time). Since

the stimuli are distributed at random over the sensor field and the values of delay components connected to the sensors are chosen at random, there will be separation of the signals in time.

A sequence of pulses will appear at the output of the OR logic circuit, and their number is recorded by means of a small capacity recording counter.

There is a probability that is other than zero that all signals formed by the activated sensors will be delayed for different time intervals and that the number of inputted stimuli will be recorded in the counter. This probability is related to the number of gradations of time lag, as well as number of stimuli.

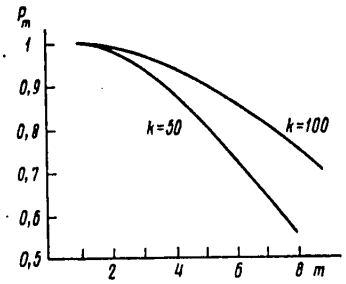

Figure 3.

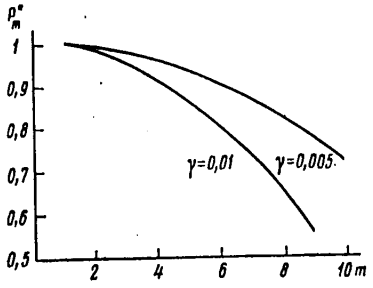

Figure 4.

The probability that all signals will have different delays, in the case of total number k of gradations of lag time and m number of inputted signals, can be determined using the following formula (see Appendix):

$$P_m = \frac{k!}{(k-m)!}\left(\frac{1}{k}\right)^m. \qquad (1)$$

Figure 2 illustrates a family of curves plotted for several values of m as a function of k number of gradations. Figure 3 illustrates the probability of correct estimation P_m as a function of number of inputted stimuli, with k = 50 and k = 100.

Analysis of these functions shows that with a small number of stimuli (m<8-10) and large number of gradations (k = 100) the probability P_m of proper estimation of number of stimuli remains rather high (P_m>0.5), but then, with increase in m, it diminishes rapidly. Such change in P_m is similar to the corresponding functions demonstrated in biological sensory systems [1].

However, the time of estimating the number of stimuli is a more important characteristic. The time in which the operating cycle is effected is determined by τ_2. The main restrictions are imposed on τ_2 by the resolution of the RC. The counter's resolution is determined with the following formula:

$$\frac{\tau_2-\tau_1}{k}>\tau_p, \tag{2}$$

where k is the number of gradations, τ_p is the resolution of the recording counter (minimal time between two signals that the counter can still perceive separately).

In view of the fact that $\tau_1>0$ and $k>0$, this inequality can be converted into $\tau_2>k\tau_p$. According to this inequality, the duration of the measuring cycle of the unit in question is determined essentially by the number of gradations and resolution of the *RC* (i.e., it does not depend on the number of sensors).

Let us dwell in greater detail on this property of the algorithm under discussion. If we take 10^{-3} s as the resolution of the *RC* (i.e., commensurable with the response time of a single neuron), with 100 gradations one can estimate the unit's response time at 10^{-1} s, which is commensurable, for example, with the speed of action of the visual analyzer, as determined in tachistoscopic experiments. Thus, analysis of this algorithm shows that its most important features resemble those of sensory systems.

From the standpoint of a physiologist, the assumption that the lag time is discrete is a very gross error. To eliminate it, let us discuss an analogue unit, in which the time lag for each component can assume any value in the range of $[\tau_1, \tau_2]$. Let us assume that time lag is a continuous random value that is uniformly distributed over $[\tau_1, \tau_2]$. In this case, restrictions on the interval between delayed signals are also imposed by the resolution of the recording counter. We shall give the resolution as a share of interval $[\tau_1, \tau_2]$:

$$\tau_p=\gamma(\tau_2-\tau_1), \tag{3}$$

where $0<\gamma\ll 1$.

As in the first variant of the unit, it can be considered that the stimuli are distributed at random over the sensor field and that each of the formed signals is delayed for a random period of time. If at least two signals are inputted in the OR circuit, which are less than τ_p apart, the *RC* will record them as one signal and there will be erroneous estimation of the number of stimuli.

When there are two stimuli on the sensor field, a problem arises that is called "encounter problem" in probability theory [4]. For m stimuli, one can formulate a multidimensional "encounter problem." In the unit under discussion, the "encounter" of two or more signals leads to an error in estimating the number of stimuli going to the sensor field. Figure 4 illustrates the probability P_m of correct estimation as a function of delivered stimuli with two values for parameter γ. This function was obtained as a result of simulating the multidimensional "encounter problem" on a computer. Analysis of the obtained functions confirms the conclusion that the algorithm in question has characteristics that are similar to the main characteristics of biological sensory systems.

APPENDIX

Derivation of Formulas [1]

Let there be N sensors, to each of which is connected a delay component. There are k gradations of time lag. Then the number of delay components for each gradation is determined by the equation, $n_i = N/k$, where $(i = 1 \div k)$. One must determine probability P_m of an event, which consists of the fact that with random choice of m delay components in a set of N elements all m elements will have different lag times.

Let us designate as A_i an event consisting of the fact that the selected delay is referable to the ith gradation. The probability of event A_i is determined by the equation:

$$P(A_i) = \frac{n_i}{N} = \frac{1}{k}. \tag{A.1}$$

Then the probability of one variant of choice m for different delays is determined by the equation:

$$P = [P(A_i)]^m = \left(\frac{1}{k}\right)^m. \tag{A.2}$$

The total number M of such variants is determined by:

$$M = C_k^m m! = \frac{k!}{(k-m)!}. \tag{A.3}$$

Ultimately, we see that the probability of choice of m different delays is determined using formula (1).

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DISTRIBUTION, HOMOLOGY AND CLONING OF CRYPTIC PLASMIDS OF BACILLUS THURINGIENSIS

Moscow GENETIKA in Russian Vol 18, No 2, Feb 82 (manuscript received 6 Oct 81) pp 181-189

[Article by V. A. Sakanyan, G. N. Selivanova, N. O. Bukanov, M. A. Krupenko and S. I. Alikhanyan, All-Union Scientific Research Institute of Genetics and Breeding of Industrial Microorganisms, Moscow]

[Text] At least seven cryptic plasmids (pBTG1-pBTG7) with molecular lengths of 8.4-15.7 kb [kilobase] were identified in Bacillus thuringiensis subsp. galleriae 69-6. According to the results of hybridization and heteroduplex analysis, the plasmids of this strain have extensive regions of homology to one another. Homology was also demonstrated between B. thuringiensis subsp. galleriae 69-6 plasmids and cryptic plasmids in 10 out of 14 tested strains of other B. thuringiensis serotypes. These data indicate that some plasmid genes are conserved in B. thuringiensis. All HindIII, BamHI and EcoRI fragments of cryptic plasmid DNA from B. thuringiensis subsp. galleriae 69-6 were cloned on vector pBR325 in Escherichia coli cells.

The sporulating soil bacterium, B. thuringiensis, produces insecticidal toxins. The most pathogenic one is crystalline δ-endotoxin, which is used as a biological agent for protecting plants against harmful insects [1]. There are still no data whatsoever concerning the genetic organization and regulation of toxin production by B. thuringiensis.

The discovery of cryptic plasmids in strains of several B. thuringiensis serotypes [2-5] and study of plasmid composition of crystalliferous and acrystalliferous strains made it possible to expound the hypothesis of plasmid determination of toxin production [2, 6]. However, there are data that fail to confirm the involvement of plasmids in synthesis of δ-endotoxin [5, 7, 8]. It was recently possible to demonstrate that plasmids of B. thuringiensis subsp. galleriae 69-6 (serotype V) code the synthesis of crystalline δ-endotoxin [9]. This prompted further studies of cryptic plasmids of B. thuringiensis.

Material and Methods

The bacterial strains used in this study are listed in Table 1. B. thuringiensis subsp. galleriae 69-6 is used in industry, while the other strains of B. thuringiensis were obtained from the culture collection of the All-Union Scientific Research Institute of Genetics. DNA was cloned in Escherichia coli HB101 r^-m^- cells on vector pBR325, which determines resistance to tetracycline, ampicillin and chloramphenicol [10].

Table 1. Strains of B. thuringiensis

Strain	Serotype	Strain	Serotype	Strain	Serotype
berliner	I(2)	galleriae	Vab	tolworthi	IX
finitimus	II	entomocidus	VI′	darmstadiensis	X
alesti	IIIa	subtoxicus	VI	toumanoffi	XI
kurstaki	IIIab	aizawai	VII	thuringiensis	I(1)
dendrolimus	IVab(1′)	morrisoni	VIII	kenyae	IVac

Media: We used Hottinger broth and 1.5% Hottinger agar. In some cases, we also used L broth and solid medium prepared on the basis of this broth by adding 15 g agar (Difco, United States) per liter medium.

Isolation of DNA: We used the method described in [11] for preparative isolation of plasmid DNA from E. coli cells, with the exception of the fact that cells were submitted to lysis using a solution containing 0.2% Triton X-100, 50 mM tris-HCl, pH 8.0, and 62.5 mM EDTA. We used the method described by Gonzalez and Carlton [5] to screen plasmid DNA in strains of different serotypes of B. thuringiensis. The same technique, with modifications, was used to isolate plasmid DNA from B. thuringiensis subsp. galleriae 69-6. Cells cultivated in 1 ℓ broth at 35°C with intensive rocking to the late logarithmic phase were collected by centrifuging under refrigeration and washed twice in cold TEN buffer (0.05 M tris-HCl, pH 8.0, 0.005 M EDTA-Na_2, 0.05 M NaCl). The cells were frozen for about 2 h at -20°C and resuspended in 100 mℓ TEN buffer containing 25% saccharose. Five min later, we added to the resuspended culture 10 mℓ freshly prepared lysozyme solution (14 mg/mℓ), and the mixture was incubated for 90 min at 37°C with gentle stirring. The cells were lyzed by addition of 100 mℓ 5% sodium dodecylsulfate (Sigma, United States) in TEN-buffer followed by incubation with gentle stirring at 65°C for up to 15 min. To the lysate we added 50 mℓ 5 M NaCl solution and continued incubation for another 5 min at 65°C. The lysate was kept overnight at 4°C and centrifuged for up to 50 min at 17,000 r/min to precipitate chromosomal DNA. To the cleared lysate, we added dry polyethyleneglycol with relative molecular mass of 6000 (Serva, FRG) to an end concentration of 10%, and the mixture was stored overnight at 4°C. Polyethyleneglycol-bound DNA was precipitated by slow (3000 r/min) centrifuging, and the precipitate was dissolved in TEN buffer. To the suspension we added dry cesium chloride (1 g/mℓ), the solution was centrifuged and the floating "protein film" was removed. We added to the solution ethidium bromide (Serva, FRG) to an end concentration of 300 μg/mℓ and brought the solution refraction index up to 1.392. Equiponderant

ultracentrifuging was performed at 44,000 r/min for up to 44 h on an L-65 centrifuge (Beckman, United States). Plasmid DNA was carefully collected from the gradient with a syringe, and to remove ethidium bromide we performed 2-3-fold extraction with isopropyl alcohol saturated with cesium chloride. To the solution we added one-third volume of 3 M sodium acetate and double volume of cold 96% ethyl alcohol. The DNA was precipitated at -20°C overnight with subsequent centrifuging. The precipitated DNA was dissolved in TE buffer (10 mM tris-HCl, pH 8.0, 1 mM EDTA-Na_2). In the experiments for cloning, plasmid DNA of B. thuringiensis and pBR325 vector were purified twice in a gradient of cesium chloride. We used the method described in [12] to analyze recombinant clones for demonstration of plasmid DNA.

Changing supercoiled closed circular molecules (CCC form) into open circular molecules of DNA (OC form); We transferred 2-6 μg plasmid DNA in 100 μl TE buffer, which contained 50 μg/ml ethidium bromide, into a quartz cuvette and exposed it to UV [ultraviolet] light at 1000 erg/$mm^2 \cdot s$ (SVD-120A lamp). We took samples at specific intervals and analyzed them by electrophoresis in 0.5% agarose gel.

Isolation of individual plasmids from agarose gel: We used several methods [13-15]. The best results were obtained with the method of Ledeboer et al. [13]. Hydroxylapatite-bound DNA was eluted by chromatography through a column with Sephadex G-50 medium (Pharmacia, Sweden) by means of 0.25 M EDTA solution, pH 8.0. Separated DNA was precipitated with 96% ethyl alcohol for >4 h at -20°C and on a microcentrifuge (Beckman, United States). The supernatant was carefully removed with a sterile Pasteur pipette; to the precipitate we added 70% ethyl alcohol and repeatedly centrifuged. The remaining fluid was evaporated in a water bath at 65°C and the sediment was dissolved in 10-20 μl TE buffer.

Electrophoresis was performed in a horizontal unit, in 0.5% agarose gel, 15×18×0.3 cm in size at a voltage of 20-200 V for 2-48 h. We used a buffer of the following composition: 0.04 M tris-base, pH 7.8, 0.02 M sodium acetate and 0.002 M EDTA. The gels were stained in the same buffer containing 1 μg/ml ethidium bromide and photographed under UV light through an OS-12 orange light filter.

We used 0.7% agarose gel for preparative electrophoresis. We applied ~10-20 μg plasmid DNA into each depression [pore, pit] 30×1.5 mm in size. Electrophoresis was pursued for 18 h at 30 V and 4°C.

Restriction and ligation of DNA: DNA was cleaved for 1-2 h at 37°C in buffers of the following composition: 20 mM tris-HCL, pH 7.0, 100 mM NaCl, 7 mM $MgCl_2$ for BamHI enzyme; 20 mM tris-HCl, pH 7.5, 60 mM NaCl, 7 mM $MgCl_2$ for HindIII and 100 mM tris-HC, pH 7.2, 50 mM NaCl, 5 mM $MgCl_2$ for EcoRI. The reaction was stopped by heating the reaction mixture at 65°C for 10 min, followed by rapid cooling in an ice bath. We added one-fifth the volume of a 5-fold solution containing 50% glycerin, 0.5% sodium dodecylsulfate and 0.25% bromphenol blue to the reaction mixture, and samples were analyzed by means of electrophoresis.

For cloning, the restricted DNA specimens were precipitated with 96% ethyl alcohol as described above, then we mixed cloned and vector DNA in a ratio of 3:1 and spliced with polynucleotide ligase of T4 phage with an end DNA concentration of 70 μg/mℓ. The reaction was run in 100 μℓ solution containing 70 mM tris-HCl, pH 7.4, 1 mM EDTA, 10 mM $MgCl_2$, 1 mM ATP (Sigma, United States), 10 mM dithiothreitol and ligase excess (20 units) at 14°C for 12 h. The reaction medium was heated at 65°C for up to 10 min and, after cooling, was used to transform competent E. coli HB101 cells.

Transformation of plasmid DNA was done by the method of Mandel and Higa [16] in the modification of Dagert and Ehrlich [17] by breeding ampicillin-resistant (100 μg/mℓ) colonies.

Transfer of DNA from agarose gel to nitrocellulose filters (type BA85, pore size 0.45 μm, Schleicher & Schuell, FRG) was performed by the method of Southern [18]. We transferred high-molecular DNA after partial depurinization [19]. The filters with transferred DNA were kept in vacuum at 80°C for up to 3 h.

Transfer of colonies to Whatman 541 paper was performed by the method described in [20].

Preparation of ^{32}P-labeled DNA: DNA was denatured by boiling at 100°C for up to 5 min followed by rapid cooling in an ice bath, then labeled by the nick translation method [21, 22]. Radioactive DNA was separated by chromatography on a column with fine Sephadex G-50 (Pharmacia, Sweden), using for elution a buffer containing 100 mM tris-HCl, pH 8.0, 50 mM NaCl, 5 mM EDTA. The specific activity of the radioactive samples constituted $0.5\text{-}2 \cdot 10^8$ counts/min/μg DNA. We used [α-^{32}P]-ATP (350 Ci/mM; 1 Ci = $3.7 \cdot 10^{10}$ becquerel (Amersham, England) and DNA polymerase I of E. coli (Bethesda Research Laboratories, United States).

Hybridization was performed in 50% deionized formamide solution containing 0.02% each of bovine serum albumin, ficoll and polyvinylpyrrolidone [23], 5-fold SSC (1-fold SSC contains 0.15 M NaCl, 0.015 M sodium citrate, pH 7.0) and 200 μg/mℓ low-molecular denatured DNA from chick erythrocytes. The reaction lasted up to 30-40 h at 37°C. After hybridization, the filters and Whatman paper 541 were eluted in a solution of 2-fold SSC containing 0.5% sodium dodecylsulfate (4 changes) and 2-5 times in a solution of 2-fold SSC for at least 5 h. Autoradiography was performed using HS11 ORWO x-ray film in cassettes ["boxes"] with an EU-V2 amplifying screen at -70°C.

Electron microscopy was performed as previously described [24].

Experimental Section

Identification of cryptic plasmids of B. thuringiensis subsp. galleriae 69-6: Examination of B. thuringiensis subsp. galleriae strains was indicative of the presence of plasmids [2, 25]. In order to determine the true number and identify the plasmids in B. thuringiensis subsp. galleriae 69-6, we conducted electrophoretic and electron microscopic analysis of

plasmid DNA of this strain. As can be seen on the electrophoregram (Figure 1 [no photos reproduced], the fraction of extrachromosomal DNA of B. thuringiensis subsp. galleriae 69-6 contains several bands, which implies the existence of several plasmids with different relative molecular mass. Since the same plasmid DNA exists in the cell in the form of structural configurations with different electrophoretic mobility, we transferred the CCC forms into OC forms of DNA. For this purpose, total plasmid DNA was exposed to UV in the presence of ethidium bromide and then analyzed in agarose gel. Figure 2 shows that exposure to UV leads to disappearance of several bands (CCC forms) and intensification of others (OC forms). In the case of prolonged irradiation, linear forms also appear, due to substantial damage to DNA.

As a result of these experiments, we identified six cryptic plasmids in B. thuringiensis subsp. galleriae 69-6. A comparison of electrophoretic mobility of OC forms of plasmid DNA to that of plasmids with known relative molecular mass yielded the relative molecular masses of the demonstrated plasmids.

These data were confirmed by electron microscopy of the plasmid DNA fraction. Measurement of contour lengths of >500 OC molecules of DNA enabled us to determine more exactly the relative mol. masses of the plasmids and discover yet another plasmid with relative mol. mass of 14.2 kb (Table 2). The cryptic plasmids of B. thuringiensis subsp. galleriae 69-6 were designated as pBTG1, pBTG2, etc., in accordance with the increase in their relative mol. mass.

Table 2. Cryptic plasmids of B. thuringiensis subsp. galleriae 69-6

Plasmid	Molecular length, kb*	Plasmid	Molecular length, kb*
pBTG1	8,4±0,20(56)	pBTG5	14,2±0,31(16)
pBTG2	8,7±0,26(200)	pBTG6	15,4±0,17(54)
pBTG3	12,9±0,29(57)	pBTG7	15,7±0,32(60)
pBTG4	13,4±0,25(77)		

*The number of OC forms of DNA measured under an electron microscope is given in parentheses.

Thus, there is wide representation in B. thuringiensis subsp. galleriae 69-6 of cryptic plasmids with relative mol. mass of 8.4 to 15.7 kb. We do not rule out the possibility that there are also higher molecular plasmids in this strain, since preparative electrophoresis in gel showed slowly migrating bands (see Figure 1), which were absent when we analyzed small amounts of DNA.

We succeeded in isolating individual cryptic plasmids of B. thuringiensis subsp. galleriae 69-6 only with regard to the pBTG2 plasmid. In all other cases, the specimens contained an admixture of plasmid DNA with similar relative mol. masses.

Homology of cryptic plasmids of B. thuringiensis: It was previously found that there are homology regions in plasmids of the same strain of B. thuringiensis [26, 27]. Our experiments described here are also indicative of

homology between the cryptic plasmids of B. thuringiensis subsp. galleriae 69-6. Figure 3 shows that ^{32}P-labeled DNA of plasmid pBTG2 is hybridized at least with DNA of plasmids pBTG1 and pBTG4. According to intensity of hybridized bands, as compared to hybridization between labeled and unlabeled DNA of plasmid pBTG2, it can be assumed that there is a high level of homology between DNA of plasmid pBTG2 and plasmids pBTG1 and pBTG4. Indeed, heteroduplex analysis enabled us to detect extended regions of homology in DNA of plasmids pBTG1 and pBTG2 (Figure 4). In all, up to 60% of the genome of these plasmids consists of homologous sequences.

It was interesting to determine whether there is homology between plasmids of strains of different serotypes of B. thuringiensis. First of all, we examined the plasmid composition of 14 strains. Figure 5*a* shows that 12 of the strains examined contain plasmid DNA, and many of them have several plasmids. At least one of the cryptic plasmids of most strains (with the exception of two representing the subspecies toumanoffi and morrisoni) are hybridized with ^{32}P-labeled DNA of plasmid pBTG2 (see Figure 5*б*). There was particularly intensive hybridization of a plasmid with relative mol. mass of ~5 MD in B. thuringiensis subsp. kurstaki. Moreover, there were several plasmids that hybridized with plasmid pBTG2 in this strain, as well as in the subspecies subtoxicus and tolworthi.

When a mixture of plasmids pBTG1, pBTG2, pBTG3 and pBTG4 (this DNA fraction was obtained from agarose gel in the course of isolating individual plasmids) was used as the ^{32}P-labeled DNA, we identified additional hybridizing bands of plasmid DNA in lysates of some subspecies of B. thuringiensis. This shows that one (some) of the pBTG1, pBTG3 and pBTG4 plasmids also has different areas of homology with DNA of cryptic plasmids of other serotypes of B. thuringiensis strains, as compared to plasmid pBTG2.

Cloning plasmid DNA of B. thuringiensis subsp. galleriae 69-6 in E. coli cells: Representation of the set of plasmids with similar relative mol. masses in B. thuringiensis subsp. galleriae 69-6 limits the possibility of physical analysis of individual plasmids. Nevertheless, restriction with total plasmid DNA reveals that some plasmids have at least one cleavage site for one of the enzymes, BamHI, HindIII or EcoRI (Figure 6).

Total DNA of cryptic plasmids treated with one of the restrictases, BamHI, HindIII or EcoRI was spliced with ligase to vector pBR325 also treated with one of the restrictases. We selected ampicillin-resistant transformants from E. coli HB101 cells, which were tested by means of colony hybridization for acquisition of fragments of cryptic plasmid DNA of B. thuringiensis (Figure 7). As a result, we selected 14, 30 and 8 recombinant clones that acquired BamHI, HindIII and EcoRI fragments, respectively, of B. thuringiensis cryptic plasmid DNA. It should be noted that cloning in the appropriate restriction site did not lead to inactivation of antibiotic resistance in all of the recombinant clones. For example, 12 clones that acquired the HindIII fragments of B. thuringiensis cryptic plasmids retained resistance to tetracycline.

Screening of recombinant clones revealed that they all acquired plasmid DNA with greater rel. mol. mass than that of initial vector pBR325. Preliminary restriction analysis of recombinant plasmids warrants the assumption that we succeeded in cloning virtually all fragments of cryptic plasmid DNA of the strain B. thuringiensis subsp. galleriae 69-6 generated by the BamHI, HindIII and EcoRI enzymes.

Discussion

Many strains of B. thuringiensis contain extrachromosomal DNA. The plasmid genes of B. thuringiensis subsp. galleriae 69-6 code synthesis of insecticidal toxin [9]. Thus far no other function has been determined for B. thuringiensis plasmids. The presence of extended regions of homology between cryptic plasmids of B. thuringiensis subsp. galleriae 69-6 warrants the assumption that the same genes are copied on independent replicons in the host strain. Moreover, homology between cryptic plasmids of different serotypes could be the result of the fact that certain plasmid DNA sequences are conserved in B. thuringiensis.

Another cause of homology of cryptic plasmids of B. thuringiensis could be related to the presence in them of mobile structures of the transposon type and insertion sequences. Debabov et al. [27], using electron microscopy, identified a transposon-like structure in one of the B. thuringiensis plasmids.

The transduction method of transmission of genetic material in B. thuringiensis cells under in vitro conditions has been described [28, 29]. Recently, transformation transfer of heterologous plasmid DNA in polyethyleneglycol-treated B. thuringiensis cells was also performed [30, 31]. Homology between plasmids of different representatives of B. thuringiensis suggests that, under natural conditions, bacteria of the genus B. thuringiensis have effective routes for exchange of genetic information.

Still unclear is the cause of broad representation of extrachromosomal DNA in B. thuringiensis cells. With reference to B. megaterium, which contains nine plasmids, the hypothesis has been expounded that extrachromosomal DNA of this strain consists of circular fragments of chromosomal DNA [32]. In order to determine the validity of this hypothesis for B. thuringiensis plasmids, experiments are currently in progress to determine the possibility of homology between extrachromosomal and chromosomal DNA.

It should be noted that the cryptic plasmids of B. thuringiensis subsp. galleriae are notable for several parameters. For example, plasmids pBTG1, pBTG3 and, perhaps, pBTG5 are isolated from cells chiefly in OC forms of DNA (see Figure 2). Sensitivity to the relaxing effect of sodium dodecylsulfate (used for cell lysis) may be related to the biological distinctions of these plasmids. Moreover, judging by the intensity of CCC and OC forms of DNA, it may be considered that plasmids pBTG1, pBTG3 and pBTG5 are present in the cell in considerably fewer copies than, for example, plasmid pBTG2. The small number of copies, as well as similar rel. mol. masses of several plasmids, were the reason why there are quite limited possibilities for studying individual B. thuringiensis plasmids at the present time.

Apparently, B. thuringiensis plasmids participate not only in synthesis of insecticidal δ-endotoxin [9], but other cellular processes. Plasmid DNA cloning in cells of a suitable recipient is the most acceptable approach to solving this and other problems. As we demonstrated previously [33], E. coli could serve as such a recipient, since we should expect expression of many B. thuringiensis genes in the cells of this Gram-negative bacterium.

In the course of preparing this article for publication, the article of Schnepf and Whiteley appeared [34], which dealt with successful cloning of plasmid genes of the crystal protein of B. thuringiensis subsp. kurstaki in E. coli cells.

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MOBILIZATION OF CHROMOSOMAL GENES OF VIBRIO CHOLERAE BY PLASMID RP4::Mu cts62

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[Text] Studies were made of the possibility of mobilization of chromosomal genes of Vibrio cholerae with plasmid RP4::Mu cts62. This plasmid was constructed in E. coli cells and then transferred to donor strains of Vibrio cholerae. It was shown that plasmid RP4::Mu cts62 mobilizes chromosomal genes of Vibrio cholerae through conjugative transmission. There is considerable increase in frequency of mobilization when crosses are produced at the semipermissive temperature for heat-inducible phage Mu cts62. This pattern is observed only with use of donors carrying plasmid RP4::Mu cts62, but not donors with plasmid RP4. The incidence of transmission of chromosomal markers by plasmid RP4::Mu cts62 per transmitted plasmid is considerably higher than the incidences characterizing the mobilizing activity of the P factor of Vibrio cholerae. No markers of plasmid RP4 and phage Mu cts62 are demonstrable in transconjugants receiving plasmid-mobilized chromosomal genes, which could be an advantage in using the obtained recombinants in studies dealing with genetic analysis of Vibrio cholerae. The causes of absence of plasmid RP4 and phage Mu cts62 markers in recombinants are discussed.

In recent years, there has been considerable intensification of genetic studies of Vibrio cholerae, and this is reflected in the published surveys [1, 2]. Use of systems of genetic hybridization of V. cholerae, in which vibrions with the P factor serve as a donor, established that there are three groups of linkages on the basis of mapping 17 genes of V. cholerae [3].

While there are obvious advances in the area of genetic studies of V. cholerae, it is just as obvious that analysis of crosses between P^+ and P^- cells is far from perfect. This circumstance has led researchers to work on new routes of genetic exchange in V. cholerae. Some progress has already been made

in this direction. In particular, so-called Tfr strains (from the English, "transposon facilitated recombination"[4, 5]) have been obtained by insertion of transposons that provide for homology in the chromosome and P factor.

The studies described here deal with development of a new system of genetic exchange in V. cholerae. To create such a system, plasmid RP4, which contains the cts mutant of phage Mu (RP4::Mu cts62), was constructed and transmitted to V. cholerae. The capacity not only of its own transmission in crosses between V. cholerae, but to mobilize chromosomal genes of V. cholerae, was found to be inherent in this plasmid. It was demonstrated that mobilization of chromosomal genes by plasmid RP4::Mu cts62 occurs much more efficiently than with plasmid RP4, and the temperature is a contributing factor.

Material and Methods

Table 1 lists the strains used in this study. Phage Mu and its mutant Mu cts62 were obtained from M. Howe (United States). This mutant of phage Mu has a ts mutation in gene C which determines heat induction of prophage (42°C) [6].

In this work, we used complete Lennox medium of the Difco Company (United States) and minimum medium A [7]. Amino acids were added to minimum medium in a concentration of 200 μg/mℓ, glucose in a concentration of 0.6%, as well as antibiotics (in μg/mℓ): tetracycline 10, ampicillin 20, kanamycin 20 and streptomycin 100. Lysogenization of cells with bacteriophage Mu and Mu cts62, as well as head induction of phage Mu cts62, was performed by the techniques described by Howe [6]. Conjugation transfer of plasmid RP4 by E. coli cells was performed by the standard method [7].

Table 1. Bacterial strains used in this study

Strain	Genotype	Plasmids	Source
E. coli: GA120	trp	–	This laboratory
W3110	thy	RP4	Collection of A. F. Moroz (Moscow)
CH111	trp ade arg B' str recA	RP4	Collection of G. B. Smirnov (Moscow)
AB2463	leu pro his arg thr B' str resA	–	P. Howard-Flanders (United States)
AB1157	arg leu pro thr his B_1 str	–	Same
KS1401	pro his tnm	–	T. S. Il'ina (Moscow)
GA570	leu pro his thr B' str recA	RP4::Mu cts 62	This laboratory
V. cholerae: 569B	Prototroph	–	Stavropol' Plague Control Institute
RV31	ilv his arg str tox	–	C. Parker (United States)
VT5101	Prototroph	RP4::Mu cts 62	This study
VT5102		RP4	Same

Experimental Section

We know that plasmid RP4 can be transmitted to bacteria of different systematic groups. This plasmid can mobilize chromosomal genes. However, the frequency of transfer of chromosomal markers with this plasmid is not high [8]. At the same time, we know that fragments of a bacterial chromosome can be incorporated in a plasmid if phage Mu is inserted in it, which carries the cts mutation, or else a chromosomal fragment. In the presence of semipermissive temperature for such a phase, there is partial induction of prophage. This increases the frequency of formation of a unique structure: a segment of a chromosome that is flanked by the genome of phage Mu is contained in the plasmid [9, 10].

In order to obtain such a system of mobilization of chromosomal genes in V. cholerae, we constructed plasmid RP4::Mu cts62. For this purpose, E. coli strain GA120 was lysogenized by phage Mu cts62. The lysogenic clone was used in crosses with E. coli strain CH111 (RP4), which served as the donor. We selected tetracycline-resistant (Tc) transcipients. Cross-selection of the donor was made on the basis of growth requirements (absence of arginine and adenine in the medium). The frequency of Tc clone formation constituted 10^{-2}-10^{-3} scaled to donor cells. All of the tested clones were Km Ap Tc, i.e., they had all the markers of plasmid RP4, heat-sensitivity imparted by phage Mu cts62 and carried the recipient's genetic marker (tryptophan dependence).

In other words, we obtained clones containing both plasmid RP4 and phage Mu cts62. One of these clones was used as a donor in a crossing to produce an RP4 plasmid containing a chromosomal fragment flanked by the genome of phage Mu.

It is known [9] that one must use RecA strains to demonstrate bacteria with such plasmids. This is attributable to the fact that chromosomal recombinations do not occur in RecA strains, and the chromosomal trait appears because of a gene contained in the plasmid.

In view of the foregoing, we used strain AB2463 recA as a recipient, after submitting it to lysogenization by phage Mu of the wild type. Lysogenization of the recipient was done in order to prevent zygotic induction of phage Mu cts62 which is transmitted as part of the plasmid. We selected the arg marker to obtain plasmid RP4 containing bacterial gene and phage Mu. Consequently, Arg^+ transcipients were submitted to selection. Cross-breeding of the donor was made by adding streptomycin to the medium.

We modified slightly the method of Faelen and Toussaint in our experiments, and conducted them as follows. Just prior to hybridization, the donor culture in the log phase of growth was incubated for 45 min at 37°C (semipermissive temperature for phage Mu cts62). Hybridization was performed at the same temperature for 3 h. When we checked the nonselective markers in the recovered Arg^+ transcipients, we found that the absolute majority (16 out of 17) carried all the markers of plasmid RP4.

Lysogenicity of the recipient prevents heat induction of phage Mu cts62. Consequently, special experiments were conducted to prove its presence in plasmid RP4. For this purpose, one of the obtained Arg^+Km Ap Tc transcipients, designated as strain GA570, was used as donor for conjugative transfer of this plasmid to E. coli KS1461 mutant. This mutant, which was kindly provided by T. S. Il'ina (Moscow) is resistant to phage Mu. This property of the mutant makes it possible for phage Mu to enter only as part of plasmid RP4 and precludes lysogenization by free phage spontaneously induced in donor cells. We submitted Km clones to selection in the GA570×KS1461 cross. Heat sensitivity of the selected clones was analyzed as a nonselective marker. All of the checked Km clones were found to be heat sensitive, resistant to tetracycline, kanamycin and ampicillin, and they retained the amino acid markers of the recipient.

Two such clones were tested for heat induction of phage. The phage titer in cultures exposed to heat (42°C) constituted 10^7 (Table 2).

Table 2. Heat induction of bacteriophage Mu cts62 in E. coli and V. cholerae cells

Strain	Phage particles per ml at	
	30°C	42°C
AB2463 (Mu cts62)	$1,5 \cdot 10^9$	$3,0 \cdot 10^8$
GC13 (RP4::Mu cts62)	$6,0 \cdot 10^9$	$1,0 \cdot 10^7$
AB1157 (Mu cts62)	$3,6 \cdot 10^9$	$1,0 \cdot 10^7$
569B (RP4::Mu cts62)	$3,0 \cdot 10^9$	$2,0 \cdot 10^4$
RV31 (RP4::Mu cts62)	$2,0 \cdot 10^9$	$1,0 \cdot 10^4$

This warranted the belief that strain GA570, which was used as donor, carries plasmid RP4, which contains phage Mu cts62. Strain GA570 was used as a donor in crosses with V. cholerae. In these experiments, V. cholerae strain 569B served as recipient.

The crosses were made on filters. Bacteria cultivated in Lennox broth to the stationary phase of growth (18 h) were applied on the filter in a 1:1 donor-recipient ratio. The filter was placed on Lennox agar and incubated for 24 h at 30°C. The conjugation mixture was then washed off the filter, and cultures were made on selective medium, which consisted of minimum agar with glucose and tetracycline.

The cultures on selective media were incubated at 30°C for 2-3 days. The frequency of plasmid transfer constituted 10^{-7}-10^{-6}. The selected Tc transcipients had all the markers of plasmid RP4. The heat sensitivity transferred by phage Mu to transcipients formed on the basis of strain 569B could not be demonstrated, since heat sensitivity was found to be inherent in this strain (no growth at 42°C). However, the presence of phage Mu cts62 was demonstrated by reproduction of heat induction. As can be seen in Table 2, heat induction of phage did occur, although with less efficiency than in E. coli. This was indicative of preservation of phage Mu in the RP4 plasmid transferred to V. cholerae.

Table 3. Frequency of transfer of plasmid and chromosomal markers with hybridization of V. cholerae strains*

Donor	Recip	Frequency of marker transfer							
		Km^R	Arg+	Ilv+	His+	Km^R	Arg+	Ilv+	His+
		incubation temp. 37°C				incubation temp. 30°C			
VT5101	RV31	$2,2 \cdot 10^{-5}$	$0,3 \cdot 10^{-5}$	$2,0 \cdot 10^{-5}$	$1,5 \cdot 10^{-5}$	$2,4 \cdot 10^{-5}$	$1,0 \cdot 10^{-7}$	$1,8 \cdot 10^{-7}$	$4,6 \cdot 10^{-6}$
VT5102	RV31	$1,2 \cdot 10^{-5}$	–	$5,0 \cdot 10^{-5}$	$8,0 \cdot 10^{-5}$	$2,6 \cdot 10^{-2}$	–	$4,8 \cdot 10^{-5}$	$9,1 \cdot 10^{-6}$
VT5101	RV31	–	$6,0 \cdot 10^{-5}$	$9,0 \cdot 10^{-5}$	$6,9 \cdot 10^{-5}$	–	$4,5 \cdot 10^{-5}$	$7,4 \cdot 10^{-5}$	$1,9 \cdot 10^{-5}$
VT5102		–	–	$3,8 \cdot 10^{-7}$	$6,0 \cdot 10^{-7}$	–	–	$1,8 \cdot 10^{-7}$	$3,4 \cdot 10^{-7}$

*In the two top lines, frequency of marker transfer is scaled to donor cells and in the two bottom lines to transferred plasmid.

One of the clones of strain 569B carrying the markers of plasmid RP4, which is sensitive to heat induction of phage, was designated as strain VT5101. The RP4 plasmid was transmitted to the same strain of V. cholerae (569B). This transfer was effected by the same technique as transfer of plasmid RP4::Mu cts62. One of the obtained clones, which contained the RP4 plasmid, was designated as VT5102.

Acquisition by V. cholerae of both the RP4 and RP4::Mu cts62 plasmids was not associated with change in their serological characteristics.

V. cholerae strains VT5101 and VT5102 were used as donors in hybridization of V. cholerae. In these experiments, multiply-marked mutant strain RV31 of V. cholerae was used as a recipient. Hybridization was performed on filters using the above-described method. The filters were incubated at 37°C. In some of the experiments, we conducted concurrent tests, in which filters with conjugating bacteria were incubated at 30°C (i.e., we did not use the semipermissive temperature for phage Mu cts62). We selected recombinants for all of the chromosomal markers of strain RV31 (Agr^+, Ilv^+His^+ recombinants). Concurrently, we selected Km recombinants (RP4 marker). The isolated recombinant clones were submitted to 2-fold purification on the same selective media, after which we analyzed nonselective markers. The results of these experiments are listed in Table 3.

We see that transfer of RP4::Mu cts62 and RP4 plasmids to cholera vibrions occurs at a frequency of 10^{-5} and 10^{-2}. This conforms to the difference in frequency of transfer of these plasmids in the experiments with E. coli (Table 4). The frequency of transfer of plasmid RP4 was considerably higher in the experiments with recipients that were not lysogenic for phage Mu (E. coli and V. cholerae) than the frequency of transfer of plasmid RP4::Mu cts62 (see Tables 3 and 4). With use of E. coli lysogenic for phage Mu as recipient, the frequency of transfer of RP4::Mu cts62 rose almost to the level inherent in the RP4 plasmid. Lysogenization of the recipient does not affect transfer of plasmid RP4 (see Table 4). V. cholerae is not sensitive to phage Mu [11]. For this reason, we did not succeed in lysogenization and conducting analogous experiments with V. cholerae.

Table 4. Frequency of transfer of plasmid and chromosomal markers in hybridization of E. coli strains*

Donor	Recipient	Kan	Pro	Leu	Arg	His
GA120 (RP4::Mu cts62)	AB2463	$4,4\cdot10^{-9}$	$3,0\cdot10^{-9}$	$1,0\cdot10^{-8}$	$6,0\cdot10^{-9}$	$6,0\cdot10^{-9}$
	AB1157	$1,0\cdot10^{-6}$	$4,0\cdot10^{-1}$	$1,2\cdot10^{-6}$	$3,0\cdot10^{-7}$	$2,5\cdot10^{-7}$
	AB2463 Mu cts62	$5,5\cdot10^{-8}$	$5,5\cdot10^{-8}$	$4,0\cdot10^{-8}$	$3,0\cdot10^{-8}$	$3,0\cdot10^{-8}$
	AB1157 Mu cts62	$1,0\cdot10^{-4}$	$3,5\cdot10^{-7}$	$1,3\cdot10^{-6}$	$5,6\cdot10^{-7}$	$4,1\cdot10^{-7}$
W3110 (RP4)	AB2463	$5,9\cdot10^{-4}$	–	–	–	–
	AB2463 Mu cts62	$4,9\cdot10^{-4}$	–	–	–	–

*Incubation temperature 37°C.

The frequency of transfer of chromosomal markers listed in Table 3 was calculated in relation to donor cells and transferred plasmids. As can be seen in the top part of this table, in the experiments with both plasmids there was a low incidence of recombinants for chromosomal markers when calculated in relation to donor cells. If, however, the frequency is calculated in relation to transferred plasmids (bottom part of the table), a considerably higher frequency of recombinants is observed in the tests with the RP4::Mu cts62 plasmid. Changing the temperature (37°C) does not affect frequency of transfer of chromosomal genes by plasmid RP4 (see Table 3). The findings were different in the experiments with RP4::Mu cts62: in this case, the frequency of formation of recombinants according to chromosomal genes increased significantly when hybridization was performed at the semipermissive temperature (37°C) for phage Mu cts62 (see Table 3).

Thus, there is an increase in frequency of transfer of chromosomal markers under the influence of temperature only in the case of the donor with RP4::Mu cts62, but not with the one that transfers the RP4 plasmid. This shows that the mode of transfer of chromosomal genes described for E. coli by Faelen and Toussaint also occurs in V. cholerae.

With reduction of V. cholerae, transfer of chromosomal markers by means of RP4::Mu cts62 (with direct selection of appropriate recombinants) occurred at about the same frequency as in the experiments with E. coli (see Tables 3 and 4).

At the same time, there was some distinction to the V. cholerae recombinants. Thus, we failed to demonstrate either markers of RP4 plasmid or heat sensitivity imparted by phage Mu cts62 in recombinants of V. cholerae selected according to chromosomal markers (Table 5). The same table shows that transcipients selected for chromosomal markers, which were obtained in experiments with a donor carrying RP4, did not have plasmid markers in only a certain number of cases. However, in the experiments with E. coli, retention of plasmid markers and the trait transferred by phage Mu cts62 depended on the recipient's genotype. Thus, in the experiments with recA recipients, 100% of the transcipients selected for chromosomal markers presented heat sensitivity and antibiotic resistance inherent in the RP4 plasmid.

In the experiments with an recA$^+$ recipient, however, only part of the transcipients carried plasmid markers (see Table 5).

Table 5. Conjugative cotransfer of RP4 and phage Mu cts62 markers in hybridization of transcipients according to chromosomal markers

Hybridization	Selective markers	Marker cotransfer, %		
		RP4	ts	RP4ts
GA120 (RP4::Mu cts62)×AB1157 recA+	His+	25	35	25
GA120 (RP4::Mu cts62)×AB2463 recA− (Mu cts62)	His+	100	100	100
	Leu+	100	100	100
VT101 (RP4::Mu cts62)×RV31 recA+	His+	0	0	0
	Ilv+	0	0	0
VT5102 (RP4)×RV31 recA+	Ilv+	31,5	–	–
GA120 (RP4::Mu cts62)×AB1157 recA+ (Mu cts62)	His+	90	–	–
	Leu+	80	–	–

Thus, while only some the transcipients lost markers of the transferred RP4::Mu cts62 plasmid in the experiments with recA$^+$ E. coli, in those with V. cholerae such loss was inherent in all of the tested transcipients.

Discussion

The submitted data indicate that plasmid RP4::Mu cts62 can be transmitted to V. cholerae. This plasmid is retained in V. cholerae cells, and the cts mutant of phage Mu contained in it is subject to heat induction. There is a considerably lower yield of phage particles with heat induction than with heat induction of the same plasmid in E. coli cells. This shows that events that are involved in heat induction of phage Mu cts62 in V. cholerae are less efficient than in E. coli. Still unclear are the processes involved in heat induction (excision or reproduction of phage), to which these events are related.

In hybridization of V. cholerae, the RP4::Mu cts62 plasmid mobilizes chromosomal genes. Transfer of chromosomal markers was established on the basis of direct selection of Arg$^+$, Ilv$^+$, His$^+$ clones (see Table 3). Such clones could be formed by bacteria with the appropriate genes in the plasmid, i.e., containing the structures described by Faelen and Toussaint [9], which constitute the RP4 plasmid with chromosomal fragments flanked by phage Mu. At the same time, the Arg$^+$, Ilv$^+$ and His$^+$ clones could appear as a result of recombination between the inserted plasmid and chromosome, i.e., these clones could be represented by chromosomal recombinants.

In the former case, we should observe a combination of acquired chromosomal and plasmid markers, as well as the marker of phage Mu. The results of analysis of clones obtained in the experiments with E. coli are an illustration of such a pattern. Most demonstrative are the data characterizing the transcipients formed on the basis of an recA recipient (see Table 4). These transcipients, which were selected for chromosomal markers, carry the markers of the RP4 plasmid in 100% of the cases and they are heat-sensitive (phage Mu cts 62 marker).

However, both the RP4 markers and heat sensitivity imparted by phage Mu cts62 are wanting in transcipients obtained from hybridization of V. cholerae selected for chromosomal markers (see Table 5).

Consequently, the RP4 plasmids with phage Mu and fragments of the bacterial chromosome transferred to V. cholerae apparently separate, and this is associated with formation of chromosomal recombinants. Evidently, this is associated with elimination of components of RP4 and phage Mu cts62. The breakdown of the complex plasmid could precede formation of recombinants, but perhaps it could be the consequence of recombination events. According to the data listed in Table 5, when E. coli is hybridized with the use of an $recA^+$ recipient, some of the selected clones, which acquired chromosomal traits, also present loss of RP4 and Mu cts62 markers. This indicates that, in the presence of recombination activity in the recipient, formation of chromosomal recombinants could also lead to dissociation of the plasmid in E. coli.

In spite of the absence of RP4 and Mu cts62 markers in recombinants for chromosomal genes, the origin of these recombinants is definitely related to transfer of chromosomal fragments by the RP4 Mu cts62 plasmid. This is indicated by the considerable increase in frequency of formation of such recombinants at a temperature of 37°C, which elicits partial induction of phage Mu (see Table 3).

The absence of plasmid and phage Mu markers in recombinant clones obtained in this manner should favor their use in studies dealing with genetic analysis of V. cholerae.

The system of hybridizations, in which donor capacity is provided by the RP4::Mu cts62 plasmid is quite efficient for V. cholerae. Transfer of this plasmid occurs at a lower frequency than transfer of the P factor, which occurs at a frequency of up to 90% [12]. At the same time, the frequency of mobilization of chromosomal genes by RP4::Mu cts62 (scaled to transferred plasmid) is quite high.

As can be seen in Table 3, this frequency constitutes $7.4\text{–}1.9 \cdot 10^{-3}$ for different markers with heat induction. Recalculation of the data of Bhaskaran and Sinha [12] for transferred P plasmids yields figures on the order of $5.0 \cdot 10^{-7}$.

We could expect better efficiency of the RP4::Mu cts62 system if conditions are developed to provide lysogenization of V. cholerae (recipients) by phage Mu. In E. coli, such lysogenization raises the frequency of transfer of RP4::Mu cts62 (see Table 3), which could be attributable to prevention of zygotic induction of phage Mu cts62 transferred with the plasmid.

Refinement of the system, in the direction of stabilizing plasmids carrying chromosomal fragments and phage Mu cts62 should make it possible to transfer V. cholerae genes to the plasmid.

In this regard, it is of particular interest to clone and analyze genes of toxigenicity and other genetic determinants, the products of which are important to the pathogenic effect of V. cholerae.

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RADIOPHYSICAL METHOD FOR DEMONSTRATING TEMPERATURE ABNORMALITIES IN HUMAN INTERNAL ORGANS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 260, No 5, Oct 81 (manuscript received 28 Apr 81) pp 1108-1110

[Article by G. S. Misezhnikov, A. G. Sel'skiy and V. B. Shteynshleyger (presented by Academician Yu. B. Kobzarev on 15 Apr 81)]

[Text] Studies were begun in recent years to determine the feasibility of using intrinsic heat emission of the human body in the radio range for medical diagnosis of inflammatory processes and oncological diseases [1]. Use is made of the fact that these diseases are associated with local elevation of temperature in the involved region (anomaly) by a few degrees.

One must use radiometers operating in the radiowave range with satisfactory penetrating capacity, for example in the decimeter range, for detection of abnormal temperature change deep in the human body. However, use of such relatively long radiowaves worsens the spatial localizing capability of the method.

We describe here a method and radiometric device [2] for detection of temperature anomalies deep in the human body, which overcome the above contradiction.

For this purpose, a dielectric lens with dielectric constant of ε_d that equals penetrability ε_T of human internal tissues is used as the antenna of the radiometer, which is focused on the area under study deep in the body. The lens is in contact with the part of the body under study, which is the immersion medium for this lens. (Let us note that an antenna in the form of a waveguide filled with dielectric is a special instance of a lens with focusing to infinity.)

The width of the focal diffraction spot (for level of 0.5 of maximum intensity) of the dielectric lens is [3]:

$$\Delta x \approx \frac{0{,}5\lambda}{\sqrt{\varepsilon_T}\sin\theta}, \qquad (1)$$

where λ is wavelength in air and 2Θ is the aperture angle of departure.

According to formula (1), when the aperture angle is large enough the width of the focal spot is $\sim \frac{\lambda}{2\sqrt{\varepsilon_T}}$ regardless of depth of the area under study.

Figure 1 illustrates the results of experiments using a dielectric lens, which were conducted at a wavelength of $\lambda = 18$ cm. We used water, the dielectric constant of which, ε_d, is close to permeability of most internal tissues with high fluid content [4], as dielectric lens and tissue equivalent (in the future, it is planned to use a solid dielectric with minimal loss and ε_d equaling ε_T of the internal human tissue under study). The measured value of Δx in the H plane is $\Delta x = 1.4$ cm (Figure 1a), which is close to the estimated value, whereas in the E plane it is somewhat higher.

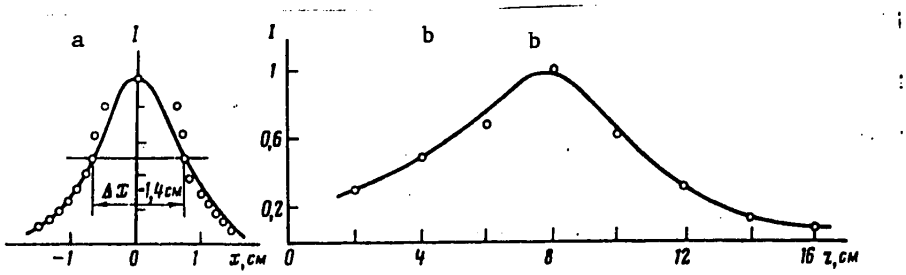

Figure 1. Distribution of field intensity in focal plane (a) and along optical axis of dielectric lens (b); a - z = 10 cm; b - λ = 18 cm; $2\Theta \approx 90°$; $\varepsilon = 80$; extinction in water ~ 0.7 dB/cm; reading from apex of lens

Localization is less accurate along the optical axis than in the focal plane. The accuracy can apparently be improved by examining the area in question from several directions and processing measurements on a computer.

When examining internal tissues, the superficial fatty layer, which is characterized by relatively low ε and minimal losses [4], causes reflection of waves from its boundaries, as well as aberration by widening the focal spot. The experiment revealed that with typical thickness (~1 cm) the equivalent of a flat adipose layer leads to insignificant widening of the focal spot, and it diminishes if the layer is spherical.

Reflections from the fatty layer have a more appreciable effect on measurement of visceral temperature, since these reflections lead to uncontrollable change in antenna temperature of the radiometer, when the antenna moves over the body, as a result of differences in thickness of the fatty layer in different parts of the body. Indeed, when using a dielectric focusing lens, antenna temperature T_a of the radiometer is determined by the following equation (for a model of the body in the form of flat layers):

$$T_a = |T_\tau + \Delta T(1-\eta_1)\eta_2 k_s|(1-|\Gamma|^2) + T_{rad}|\Gamma|^2, \qquad (2)$$

where T_T is body temperature; ΔT is local elevation of body temperature in abnormal region; η_1 and η_2 are power transmission coefficients for an anomalous layer with thickness Δl and for a layer of tissue with thickness l, respectively, which separates the abnormal region from the fat layer at the place of contact between the lens and body; $k_\beta \leqslant 1$ is the coefficient of filling of focal spot cross section by anomaly; Γ is the coefficient of reflection from the fatty layer; T_{rad} is the temperature characterizing intensity of radiometer noises emitted by its antenna.

Thus, antenna temperature depends not only on body temperature, but on the unknown Γ.

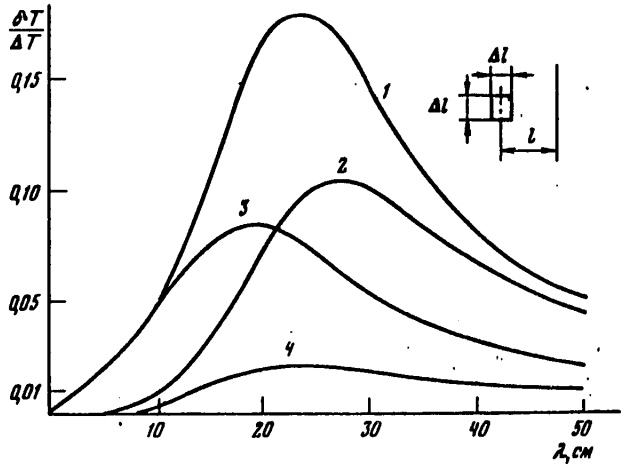

Figure 2. Increment of antenna temperature as a function of operating wavelength. In our estimates, we took $\varepsilon_d = \varepsilon_T = 50$; $2\Theta = 90°$

1) Δl = 3 cm, l = 5 cm, tan δ = 0.15
2) Δl = 3 cm, l = 5 cm, tan δ = 0.3
3) Δl = 2 cm, l = 3 cm, tan δ = 0.3
4) Δl = 2 cm, l = 5 cm, tan δ = 0.3

Measurement error related to reflection from the fatty layer can be reduced if noise is fed into the antenna through the ferrite circulator at the input of the radiometer, the intensity of which, T_{rad}, is set (by means of a special automatic regulating system [5]) at the intensity of the recorded heat emission of the body.

Comparing temperature readings in symmetrical points of the body is an additional means of compensation for the effects of reflections.

With elimination of the above error, the unit's (radiothermograph's) capacity to detect slight temperature abnormalities is determined by its sensitivity to fluctuations, which is rather high in modern radiometers and constitutes hundredths of a degree. When the reflection effects are compensated by means of an impedance transformer in the SHF circuit of the radiometer, increment

δT_a of antenna temperature caused by local elevation ΔT of temperature in the region of the anomaly is determined by the dimensions of the anomaly, absorption in the layer separating it from the surface of the body and, according to equation (2), it constitutes:

$$\delta T_a = \Delta T(1-\eta_1)\eta_2 k_s. \qquad (3)$$

Calculations, using equation (3), of some typical values of parameters Δl, l and tangent of angle of loss in body tissues, tan δ lead to the optimum operating wavelength λ_{opt} = 20-30 cm (Figure 2); with $\lambda<\lambda_{opt}$, the value of δT_a diminishes due to increased absorption in tissues and, with $\lambda>\lambda_{opt}$, due to increase in size of the focal spot.

Evidently, one can improve the diagnostic capability of the instrument by using SHF hyperthermia, since this heats the tumor to higher temperatures than healthy tissue [6]. It is particularly convenient to use hyperthermia in the described instrument: due to concentration of energy in the lenticular focus (Figure 1), there will be less heating of surrounding tissues with hyperthermia than without the lens.

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CLONING AND IDENTIFICATION OF THE GENE OF HUMAN LEUKOCYTIC INTERFERON USING SYNTHETIC OLIGONUCLEOTIDES AS PRIMER AND PROBE

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 262, No 3, Jan 82
(Manuscript received 16 Dec 81) pp 725-728

[Article by Academician Yu. A. Ovchinnikov, Ye. D. Sverdlov, S. A. Tsarev, Ye. M. Khodkova, G. S. Monastyrskaya, V. A. Yefimov, O. G. Chakhmakhcheva, V. D. Solov'yev, active member of the USSR Academy of Medical Sciences, V. P. Kuznetsov and V. M. Kavsan, Institute of Bioorganic Chemistry imeni M. M. Shemyakin, USSR Academy of Sciences, Moscow; Institute of Epidemiology and Microbiology imeni N. F. Gamaleya, USSR Academy of Medical Sciences, Moscow; and Institute of Molecular Biology and Genetics, Ukrainian Academy of Sciences, Kiev]

[Text] One of the most important problems of modern biotechnology is microbiological synthesis of human interferons with the use of producer strains obtained by gene engineering methods. Recently, the structures of several genes of leukocytic interferons [1, 2] and gene of fibroblast interferon [3] have been published. Producer strains, which synthesize up to 10^8 units of interferon per liter bacterial medium, have also been described.[4]. In all these cases, the pBR 322 plasmid was used, which was split with restriction endonuclease PstI with subsequent build-up of poly-dG and poly-dC ends on the plasmid and insert, respectively.

We cloned one of the genes of human leukocytic interferon in the HindIII segment of pBR 322 DNA. The cDNA, which was rich in interferon sequences, was synthesized with the use of synthetic oligonucleotide primer for reverse transcription. Selection of recombinant clones was made using another synthetic oligonucleotide as a probe.

Total mRNA was obtained from human blood leukocytes induced with Newcastle virus by the guanidine chloride--guanidine thiocyanate method [5]. We obtained the poly-A fraction of mRNA by two-fold purification on oligo-dT cellulose (P. L. type 7). In a typical experiment, we obtained 400 μg poly-A^+ of mRNA out of 10^{11} leukocyte cells, which was then used as template for reverse transcription without further purification. Such mRNA had an average specific activity determined according to translation in oocytes of 1000-2000 units of activity per μg RNA.*

*Determination of mRNA activity was made in the laboratories of K. T. Gazaryan (Department of Embryology, Moscow State University imeni M. V. Lomonosov) and T. G. Orlova (Institute of Epidemiology and Microbiology imeni N. F. Gamaleya, USSR Academy of Medical Sciences).

We synthesized cDNA in the following manner. We primed [or neutralized] in 200 µl 0.4 M KCl, by means of gradual cooling from 65 to 42°C, 100 µg mRNA and 120 pM synthetic oligonucleotide dGAGTTTATTCCTTCCT, with a ^{32}P-labeled 5'-end element, the 3'-end part of which is complementary to most interferon genes described in the region of termination of translation (575-560). Synthesis was performed in a buffer containing 50 mM tris-HCl, pH 8.3, 6 mM $MgCl_2$, 5 mM DTT, 80 mM KCl, a mixture of four deoxynucleoside triphosphates--0,5 mM of each, 500 units of activity of AMV reverse transcriptase for 1 h at 42°C. Upon termination of synthesis, the mixture was treated with 0.3 M alkali at 70°C for 20 min and the obtained single-strand DNA was separated by electrophoresis in denaturing 7.5% PAAG [expansion unknown], using pBR 322 DNA, split with AluI restriction endonuclease as reference points. A fraction of DNA 650 to 900 nucleotides in length was eluted and used to synthesize the second chain using a fragment of Klenov DNA polymerase I. The synthesized double-chain cDNA was split with BspI restriction endonuclease to remove the terminal single-chain "pin" and separated in 7.5% PAAG. The region corresponding to 450-600 p.o. [oligonucleotide sequences?] was eluted,

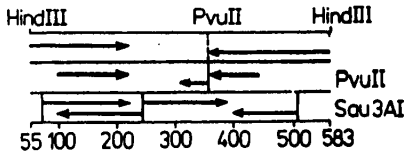

Figure 1.
Diagram for determining sequences of cloned gene of human leukocytic interferon. Arrows show length established with each given segregation of sequence. Numbering of nucleotides is the same as in [2].

As a result of these operations, we obtained 2 µg cDNA, to which we connected HindIII linkers by the method in [6] and inserted plasmid pBR 322, split by HindIII endonuclease and treated with phosphatase [6]. The mixture obtained after linkage was used to transform E. coli K802. After plating on nitrocellulose filters by the method in [7], we obtained 30,000 Ap^rTc^s transformants.

The colonies containing plasmids with inserted cDNA, which was obtained as a result of elongation of the primer used, were identified by means of hybridization on filters with the same primer labeled with ^{32}P [8]. Of the 30,000 colonies we analyzed, we selected 40 that gave a positive response. The plasmids from clones thus selected were submitted to further analysis by means of splitting with PvuII restriction endonuclease. We know from published data [2] that virtually all interferon genes contain a highly conservative site for splitting this endonuclease. The pBR 322 plasmid vector also contains one site for PvuII splitting. As a result, recombinant plasmids containing interferon genes should have two loci for PvuII segregation, and they can be readily identified by the electrophoretic mobility of fragments that are formed when they undergo hydrolysis.

As a result of such analysis, we selected six clones containing plasmids with two PvuII sites. Provided that the inserted fragment contains the complete structural gene for mature interferon, its length should be at least 500 p.o. We determined the length of the inserts in the selected plasmids by means of separation thereof with HindIII restriction endonuclease and comparison of electrophoretic mobility of the formed fragments to a set of reference material with known length. As a result, we selected three clones that met the above requirements.

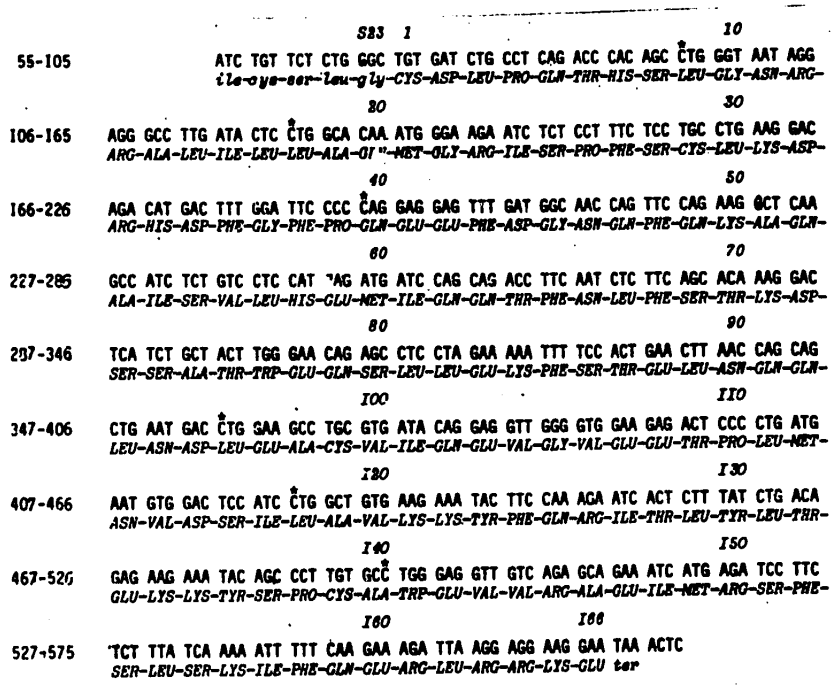

Figure 2. Nucleotide sequence of clone gene for human leukocytic interferon and its amino acid sequence. The sequence is given for complementary DNA chain adequate to the mRNA sequence. The amino acid sequence of mature interferon is given in upper case letters, and the part corresponding to the precursor is shown in lower case. Numbering of nucleotides and amino acids is that adopted in [2]. C*--5-methylcytidine residues

For making the final choice, as well as simplification of analysis of the representative group of clones (about 40,000)* obtained by this time by other methods, we synthesized a second 16-link oligonucleotide dTCTCATGATTTCTGCT, the structure of which corresponds to a segment with the same sequence in all known interferon genes (520-505). Hybridization of the above-described three clones with this oligonucleotide, whose 5'-end link was labeled with ^{32}P, enabled us to identify one clone, from which we isolated a recombinant plasmid. The primary structure of the inserted fragment was identified by our modification [9] of the Maxam and Gilbert method [10].

*These clones were obtained by reverse transcription of mRNA with oligo-(dT) as primer and insertion of the obtained cDNA in the PstI site of pBR 322 by the poly-dG--poly-dC method [11]. The structures of genes found in this case and their differences from those described in [2] will be published separately.

Figure 1 illustrates the diagram for determining sequences. A particular sequence is illustrated in Figure 2. A comparison of this sequence to known structures [2] enables us to conclude that we cloned the gene for human leukocytic interferon F. The cloned gene contains 15 nucleotides from the precursor region and differs from the native gene described in [2] with regard to structure of the terminating codon (TGA in the described structure and TAA in ours) and four nucleotides following the terminator (AACC in the described structure and ACTC in the one given here). These differences are attributable to a structural difference in the primer used and inserted in cDNA through reverse transcription, as compared to the same region of the native gene.

In addition, we demonstrated four deviations from the described structure in the internal region of the gene. In the published structure, A is in position 190 and according to our data G is located there. In all other described interferon genes, G is also found in this position, which enables us to conclude that this nucleotide is highly conservative. We do not know why there is a difference between the structure of the interferon F gene in [2] and other genes, but in our case the structure of this region was determined over two complementary chains. Guanosine is demonstrable in the site in question of the chain corresponding in sequence to mRNA, whereas 5-methyl cytidine is found in the complementary chain, which is usually encountered in $CC^{T}_{A}GG$ sequences and determination of which often leads to errors. Interestingly enough, the next discrepancies are also in the $CC^{T}_{A}GG$ sequences. We refer to position 356, where we found m^5C, whereas A was found in [2]. In most other interferon genes, C is in this position, as we also found it to be. In addition, this refers to positions 422 and 490, where T is contained in the published structure and m^5C was found in our study. It is only in the second of all four cases (position 356) that the discrepancy in nucleotide sequence leads to a substitution of amino acid. In the structure of interferon F, the authors of [2] found methionine in position 96, whereas according to our data leucine is found, as in all other interferons. The accuracy of the structure described here is based on determination of the sequence of this region over two complementary chains.

The authors express their profound gratitude to Prof V. G. Debabov, Yu. I. Kozlov, B. A. Rebentish (All-Union Scientific Research Institute of Genetics and Breeding of Industrial Microorganisms) for their constant great assistance in our work and to A. I. Petrenko (Institute of Molecular Biology and Genetics, Ukrainian Academy of Sciences) who participated in recovery of cDNA.

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FTORAFUR, AN ANTINEOPLASTIC AGENT

Moscow PROTIVOOPUKHOLEVYY PREPARAT FTORAFUR in Russian 1981 (signed to press 16 Oct 80) pp 2-4, 136

[Annotation, introduction and table of contents from book "The Antitumor Agent, Ftorafur", by Nadezhda Germanovna Blokhina, Bagrat Tiranovich Garibdzhanyan, Morgeris Yur'yevich Lidak and Anatoliy Borisovich Syrkin, USSR Academy of Medical Sciences, Izdatel'stvo "Meditsina", 1381 copies, 136 pages, illustrated]

[Text] This monograph deals with one of the active antineoplastic agents, ftorafur [1-(2-tetrahydrofuryl)-5-fluorouracil], which was synthesized in 1967 by Prof S. A. Giller, Academician of the Latvian Academy of Sciences, et al. This agent is an original chemical compound with heterocyclic structure, and it has a marked antineoplastic effect with moderate toxicity. Experimental studies of ftorafur revealed that the spectrum of its antitumor action is similar to that of 5-fluorouracil, but it has less marked side-effects. Ftorafur has no persistent deleterious effect on normal tissues of different organs and systems, and it has no cumulative toxic effect. Its capacity to penetrate the blood-brain barrier is one of the distinctive properties of ftorafur. Clinical studies revealed that ftorafur has marked antitumor activity in the treatment of tumors of the gastrointestinal tract, breast and brain. Use of ftorafur in accordance with the refined method of treatment elicits a good antineoplastic effect with minimal side-effects. At the present time, ftorafur is used extensively in oncological practice, both in the Soviet Union and abroad. This monograph is intended for clinical and experimental oncologists. It has 13 figures, 24 tables and 101 references.

Introduction

> The authors dedicate their work to the bright memory of Solomon Aronovich Giller, academician of the Latvian Academy of Sciences.

Slightly over 10 years have passed since a new antitumor agent, ftorafur, was synthesized at the Institute of Organic Synthesis, Latvian Academy of Sciences, under the guidance of S. A. Giller, academician of the Latvian Academy of Sciences.

This agent drew the attention of chemotherapists and clinical oncologists as a new compound with original pharmacological properties and high antineoplastic activity. Ftorafur was submitted to comprehensive investigation. By now, many works have been published that deal with experimental and clinical studies of this agent.

Ftorafur is allowed for medical purposes and it is used in the treatment of a number of malignant tumors in the USSR, Hungary, Poland, Czechoslovakia, Yugoslavia, Japan and a number of other countries.

However, many aspects of the mechanism of action of ftorafur, as well as its capabilities as an antineoplastic agent, have not yet been definitively determined. Studies of this agent are growing.

In view of the foregoing, it was deemed desirable to sum up the preliminary results of studying ftorafur, in order to point out the inadequacies of some aspects of investigation of this product and determine the most promising directions of future research.

In this monograph, attention is focused chiefly on the results of clinical use of ftorafur. In addition, the principal information is given about the chemistry, metabolism, pharmacokinetics and toxicology of ftorafur. The results of studying its biochemical action and effects on animal tumors are submitted. Reference was made primarily to experimental data that could be of interest and considered in clinical studies.

The authors will be grateful to specialists who will read this book, for all comments and suggestions on future studies of the promising Soviet antineoplastic agent, ftorafur.

Contents

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INTENSIVE PROCESSING OF MEDICINAL RAW MATERIALS

Moscow INTENSIVNAYA OBRABOTKA LEKARSTVENNOGO SYR'YA in Russian 1981 (signed to press 17 Aug 81) pp 2-4, 204-205

[Annotation, foreword and table of contents from book "Intensive Processing of Medicinal Raw Material", by Gennadiy Ivanovich Molchanov, Izdatel'stvo "Meditsina", 2184 copies, 206 pages]

[Text] Annotation

The present book provides the first systematized information on modern physical methods for intensifying technological processes in industrial and pharmacy-scale manufacture of medicinals: frequency (subsonic) vibrations, pulsed and superhigh frequency effects, electrical and magnetic fields. The possibilities are considered for utilizing physical methods to intensify heat and mass exchange in drying, dialysis, dispersion, filtration, sterilization and extraction of biologically-active substances and in other operations used in contemporary medicinal technology.

General information is provided on new electrophysical methods for processing medicinal raw material, intermediates of plant, animal and mineral origin; brief information is given on energy generators and certain economic bases for individual processing methods.

Considerable attention is devoted to the dependence of the physical properties of medicinal raw material upon external factors; information is presented on the change in temperature and hydrodynamics of the medium during extraction, the theoretical foundations of various technological processes are provided, their instrumentation described, and so on. The methods examined for intensive processing of raw material are highly progressive and worthwhile for the production not only of medicines but also of many other products used in the national economy. Use is made both of information published in the Soviet and foreign literature and of data experimentally obtained by the author.

The book is intended for engineers and technologists, builders of chemico-pharmaceutical factories and workers at pharmaceutical scientific research institutes and universities concerned with questions of medicinal production and investigation.

The book contains 68 illustrations and a bibliography of 159 titles.

Reviewed by G. S. Bashura, doctor of pharmaceutical sciences, professor and department head at the Khar'kov Scientific Research Institute of Chemicopharmaceuticals.

Foreword

In the reports of the 26th CPSU Congress it is stated that the efficiency of modern manufacture is closely tied to the accelerated introduction of new technological processes permitting the rational utilization of reprocessable raw material. The expansion of finished-drug production in the 11th Five-Year Plan requires comprehensive theoretical and applied study to create new technology for the extraction, separation, adsorption, dispersion and fine purification of various systems on the basis of the utilization of new physical and electrophysical methods.

The present monograph is the first Soviet work to describe the contemporary state and prospects for the utilization in pharmacy of nontraditional methods of medicinal raw material processing: broad-range frequency vibrations (from subsonic to superhigh), electrical and magnetic fields, pulse methods, raw material extraction with liquefied gases for selective removal of substances, and so on.

Each of these methods is used to some extent both in chemicopharmaceutical manufacture and in other realms of the national economy. The effectiveness of certain of the methods has as yet been established only under laboratory conditions.

Since many traditional methods and technological processes widely used in pharmacy have reached their natural limit and afford no possibility of increasing the rate of mechanical and hydrodynamic processing of raw material and enhancing thermoconductivity, mass transfer, etc., it has naturally become necessary to search for new, more intensive methods of processing medicinal raw material.

However, certain gaps are still apparent both in the theory of development of new technological raw material processing methods and in their practical utilization in production. This is to some extent due to the fact than an inexcusably small place in medicinal technology textbooks is given to new physical methods for intensifying technological processes, while curricula lack a specially designated course studying the foundations of the theory and practice of these methods.

In light of the foregoing, the present book attempts to generalize the scattered information about the utilization of new physical methods for intensifying technological processes in pharmacy. The term intensify is understood to mean not only the acceleration of any particular stage or process, but also the rationality or effectiveness of application of any type of treatment with the aim of directed conduct of the process.

The contents of the present book are a logical extension of an earlier publication*, which adequately described the theory, practice and potential application of ultrasound in pharmacy. This method of intensifying technological processes is therefore not examined in the present book.

Unfortunately, certain of the physical methods described in the book are not utilized in pharmacy. But the advantages of these methods are obvious. This is evidenced by the results of our investigations conducted with modern electrophysical equipment in laboratories at various institutions and universities in the country.

The author considers it his duty to express deep gratitude for valuable advice and assistance rendered during the preparation of the manuscript by Corresponding-Member, USSR Academy of Pedagogical Sciences, Professor Ye. M. Kozhevnikov, Corresponding-Member, Ukrainian SSR Academy of Sciences, Professor I. L. Povkh and Doctor of Technical Sciences, Professor A. I. Rogov. The author is also grateful to Doctors of Sciences, Professors G. A. Aksel'rud, M. G. Granovskiy, G. A. Gulom, I. S. Lavrov, V. I. Klassen and I. A. Murav'yev and to Candidates of Sciences, Docents L. G. Aleksandrov, A. V. Pekhov, A. D. Molchanov, Yu. G. Pshukov, V. M. Vazagov and engineer V. I. Saprykin for affording the author the possibility of familiarizing himself with work in their departments and institutions, of utilizing certain of the materials in the present book, and, also, for technical assistance rendered in the book's preparation.

The author will be grateful for all comments and suggestions that the reader of this book may feel able to communicate to him.

Table of Contents

*G. I. Molchanov, "Ul'trazvuk v Farmatsii" [Ultrasound in Pharmacy], Moscow, Meditsina, 1980.

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SCIENTIFIC LABOR ORGANIZATION IN PHARMACEUTICAL PRODUCTION

Moscow NAUCHNAYA ORGANIZATSIYA TRUDA V FARMATSEVTICHESKOM PROIZVODSTVE in Russian 1981 (signed to press 22 Jul 81) pp 2-5, 224

[Annotation, introduction and table of contents from book "Scientific Organization of Labor in Pharmaceutical Production", by Lev Viktorovich Berg, Yuriy Vasil'yevich Efimchenko and Mikhail Yur'yevich Efimchenko, Izdatel'stvo "Meditsina", 2827 copies, 224 pages]

[Text] Annotation

The monograph describes the basic principles, tasks and directions in the scientific organization of labor (NOT). Methodological foundations are provided for analyzing the state and quantitative evaluation of level of NOT in pharmaceutical enterprises. The results are presented of a completed analysis (including division and coordination of labor, demonstration of rational labor techniques and methods, labor conditions, organization and servicing of work sites, labor norm-setting, organization of socialist competition, determination of the level of labor organization attained in an enterprise as a whole, advanced experience of work on the improvement of labor organization).

The greater part of the material presented is the result of the authors' original theoretical and experimental investigations; the monograph is illustrated by specific examples and is provided with practical recommendations. It is intended for specialists in pharmaceutical and chemicopharmaceutical enterprises, pharmaceutical administrations, and, also, in analytical control laboratories involved in the organization of production and labor in pharmaceutical production.

Introduction

At the present time, attainment of the basic objectives of the Party's economic strategy, formulated by the 26th CPSU Congress, is closely tied to the acceleration of scientific and technological progress, an increase in the role of intensive factors of economic development and improved regulation of the national economy.

The Decree of 12 July 1979 of the CPSU Central Committee "Further Improvement of the Economic Mechanism and Tasks of Party and Government Organs" and the Decree of 12 July 1979 of the CPSU Central Committee and USSR Council of Ministers "Improvement of Planning and Intensification of the Impact of the Economic Mechanism upon Increasing the Production Efficiency and Work Quality" pointed out specific means to achieve reserves of increase in production efficiency.

One such means is to continuously improve the organization of labor and to achieve on this basis a rise in labor productivity and an improvement in other economic parameters of the activity of the enterprises.

The community of principles, directions and factors in the scientific organization of labor (NOT) predetermines the identical nature of work methods in this area at enterprises in different branches of the national economy. In other words the principles, directions and factors of NOT are of an interbranch character. At the same time, features of technology, production organization and enterprise specialization that are peculiar to a branch make for large differences in the methods and means of approaching identical problems associated with the improvement of labor organization. This situation is entirely pertinent to pharmaceutical enterprises (factories and plants) included in the system of the Main Pharmaceutical Administration of the USSR Ministry of Health.

At the present time most drugs are produced at the chemicopharmaceutical factories of the medical industry. Pharmaceutical enterprises of pharmaceutical administrations operate parallel to chemicopharmaceutical factories but do not duplicate their activity; rather, they have been designed for reprocessing local vegetative and other raw material, packaging certain types of products supplied by factories of the Ministry of the Medical Industry and other ministries and preparing drugs from prescriptions frequently recurring in pharmacies. Thus, pharmaceutical enterprises were created for the maximal utilization of local raw material, the elimination of redundant transport of raw material and prepared products and the liquidation of unsuitable transport of drugs in packaged form for long distances. These enterprises must release their products in volumes that generally match the consumption of a single oblast (kray).

As of 1 January 1980, there were 88 active pharmaceutical enterprises in the pharmaceutical administrative system of the Union Republic health ministries. These enterprises annually provide the nation's pharmaceutical network and therapeutic and prophylactic institutions with products worth more than 110 million rubles, prepare more than 24,000 tons of galenic products and about 800 million units of prepared drugs [37].

The regionality and specificity of the tasks of pharmaceutical enterprises predetermine their low rate of product release (most frequently from 0.5 to 2 million rubles per year) and high diversity of released products (about 200 items). With respect to product volume, pharmaceutical enterprises belong to the small category with insignificant engineering and technical staffs, in which in practice it is difficult to find even one specialist in the NOT field.

The diversity and small volume of released products predetermine a small-scale type of production, which necessitates frequent equipment readjustment (for example, in mechanized product packaging). At the same time, certain jobs (preparation of cardboard packaging, manual drug packaging, washing of glass containers) are characterized by a high degree of labor monotony [14].

Many pharmaceutical enterprises were constructed according to plans that do not meet modern requirements and were not fully provided with modern equipment and technological and organizational accouterments. In order to rectify this situation, 22 new factories have been built and 20 active enterprises reconstructed during the last 10 years. Also, the features of pharmaceutical enterprises and the conditions of their activity necessitate great systematic efforts to improve the organization of labor and production in order to enhance the functional efficiency of the respective enterprises.

Work in the field of labor organization has seen continued development in pharmaceutical enterprises in recent years. According to preliminary calculations the introduction of NOT measures accounted for a mean annual growth in labor productivity of 0.7-0.8%. The content of the work conducted has also been enriched: problems in the improvement of labor organization are more frequently resolved on the scale of a section, shop and whole enterprise.

With each year increasing attention is given to the organization of labor. This is shown by the publication of a book [36] and separate articles [18, 20, 37] devoted to the activity of pharmaceutical enterprises and institutions in the field of labor organization. The present book describes the results of investigations using information from pharmaceutical factories in the RSFSR, the Ukraine and Kazakhstan relating to an analysis of the state of labor organization and a generalization of advanced accumulated experience. Special attention in the book is given to methodological questions in the study, analysis planning and introduction of SOL. Material in the book was divided among the authors in the following manner. L. V. Berg: first section in Chapter 1, second section in Chapter 2, second section in Chapter 3, third section in Chapter 5, second, third and fifth sections in Chapter 7, second section in Chapter 9, first section in Chapter 10 (jointly with Yu. V. Efimchenko) and the second and third sections in Chapter 10; Yu. V. Efimchenko: introduction, third section in Chapter 2, first, second, fourth and fifth sections in Chapter 5, first section in Chapter 7, first section in Chapter 9 and first section in Chapter 10 (jointly with L. V. Berg); M. Yu. Efimchenko: second section in Chapter 1, first, fourth and fifth sections in Chapter 2, first section in Chapters 3, 4 and 6 and fourth section in Chapter 7.

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PHYSIOLOGY AND HYGIENE OF PERSONAL PROTECTION AGAINST COLD FOR MAN

Moscow FIZIOLOGIYA I GIGIYENA INDIVIDUAL'NOY ZASHCHITY CHELOVEKA OT KHOLODA in Russian 1981 (signed to press 12 Aug 81) pp 2-6, 288

[Annotation, introduction and table of contents from book "Physiology and Hygiene of Personal Protection Against Cold for Man" by Viktor Semenovich Koshcheyev, Izdatel'stvo "Meditsina", 5,000 copies, 288 pages]

[Text] This book acquaints the reader with the basic aspects of affording protection to man in low temperatures. It generalizes the experience acquired by the author and his colleagues over a period of many years in physiological and hygienic research on heat exchange in response to general and local cooling of varying intensity and duration, as well as in response to the combined action of cold and other factors.

The data acquired by the author's collective is used as a basis for an attempt to substantiate the tactics of individual protection for man in a cold environment and in water, and to develop the principles of creating and operating different forms of personal protective equipment, to include resources employing manmade systems for heat regulation.

The book presents the latest achievements in designing winter gear here in our country and abroad, and it recommends literature that may be used as a guide for developing, making and operating personal protective resources.

This monograph is intended for biological scientists, physicians, physiologists, hygienists, engineers, designers and so on, and specialists of the national economy dealing with the problem of developing regions of our country with a severe climate.

The book contains 95 figures and 60 tables.

The bibliography contains 288 titles.

Reviewer: USSR Academy of Medical Sciences Academician V. P. Kaznacheyev.

Contents

Introduction

The working conditions encountered in various industrial sectors, in aviation and cosmonautics, and development of Arctic and sub-Arctic regions, in exploration of the Antarctic and the World Ocean and so on are such that man may experience stresses from temperature factors. The complex of natural and production factors influencing the body's heat exchange with the surrounding environment is rather large. They include temperature, humidity, wind, insolation and so on. Separately or in different combinations, each of these factors often causes excessive accumulation of heat, or its intense loss.

Among climatic factors, cold has an especially unfavorable influence upon the body. We can get used to anything, experienced polar explorers assure us, except to cold. In the course of mammalian evolution, stable adaptation to low environmental temperature developed not along the lines of increasing the body's heat production, but rather alteration of the mechanisms responsible for physical heat regulation with the purpose of reducing heat transfer (development of a hairy integument or a sizeable layer of fat on terrestrial and aquatic inhabitants of the earth's cold regions, and so on). As we know, in evolutionary respects man is a subtropical animal, and he does not possess sufficiently effective resources by which to adapt to cold. As a rule he maintains thermal equilibrium by means of individual and collective protective resources.

In view of the geographic position of our country, about two-thirds of its population is in perpetual contact with a broad range of cold--from moderate to very intense. In a certain period of the year the labor and health of people in a number of regions are essentially fully dependent on the level of technical development, the type of personal protective gear available and shelter.

Most explorers of the Arctic, sub-Arctic and Antarctic note that the success of their expeditions has been dependent not so much on the degree to which people acclimate themselves as on the material and technical gear provided to them--primarily resources offering protection against cold (161,162,211).

Use of personal protective resources (SIZ)* has become one of the invariable technical measures of preventing overcooling of the body and ensuring safe working conditions. The need for such resources is acutely sensed both on and off the job; in the Arctic and Antarctic, moreover, this need is almost constant, while in sub-Arctic regions, which contain all of Siberia and the country's northeast (including Kamchatka), this need persists for a sizeable part of the year.

Personal protective gear acquires special importance in emergency situations, particularly when an individual is immersed in water, when the possibility that the whole body would be subjected to vitally hazardous chilling is very large, and in cases where disaster survivors are compelled to remain for a long period of time in boats or on rafts, exposed to the influences of cold water and wind. Such extreme situations also include emergency abandonment of aircraft at high altitude, when low temperature combined with the high rate of air flow about the parachute jumper may lead to general and local overchilling coupled with significant freezing of the face, hands or other portions of the body.

Each year the gear is becoming increasingly more complex, since it has now become multipurpose--that is, it is intended to provide reliable protection in various environmental conditions. Modern industry needs personal resources that could combine protection against cold with protection against harmful production factors: caustic and toxic substances in chemical industry, radioactive substances in atomic industry and so on.

*Abbreviations commonly accepted in applied physiology are used here and subsequently: KPD--efficiency, STT--mean body temperature, TsNS--central nervous system, SSS--cardiovascular system, VND--higher nervous activity, SVT--mean-weighted temperature, and so on (editor's note).

The problem of creating such gear is made more complex as a rule by the need for satisfying a large number of requirements, sometimes highly contradictory. For example the winter protective clothing used by workers in chemical industry must be low in weight, its capacity for providing protection against heat must be great, its permeability to air must be low while being highly permeable to moisture, it must keep caustic components from coming in contact with the skin while concurrently not providing an obstacle to removal of moisture from the body surface, it must protect against overcooling at rest and not elicit overheating during work, and so on.

As protective articles become more and more complex, an increasingly larger number of collectives are being asked to work on this problem, which is no longer within the means of the designers alone. This is why physiologists, hygienists, design engineers, materials scientists, physicists, chemists, mathematicians and other specialists are now participating in the development of protective resources. Today, the institutions working on personal protective gear are entire scientific-production complexes in which the scientific research is well organized. They possess a modern experimental base making it possible to simulate man's presence in different extreme environments, and specialized design subdivisions with a good experimental industrial base.

It should be remembered that no design concept is perfect if it is not founded on a knowledge of human hygiene and normal and pathological physiology.

Physiological-hygienic research conducted in the course of developing and evaluating personal protective resources in the laboratory and under production conditions makes it possible to create thermal comfort for man in a broad range of temperatures and thus maintain labor productivity at a high level and regulate the time and nature of work in personal protective resources on a scientific basis. When a person is allowed to work intensively to exhaustion and then resume such work after an amount of rest determined by the worker only on the basis of his own subjective opinion of his state, the functional possibilities of his body will in time exhaust themselves; this is why it is extremely important to develop physiological criteria for regulating the time of work and rest in personal protective resources. Using such criteria, we can find and maintain an optimum relationship between the functional stress experienced by the body and its performance in cold--that is, we can help to solve the problem of optimizing man's work in personal protective gear.

Interpreting personal protective resources as an artificial environment separating man from the external conditions, we cannot fail to account for the influence these resources have on the body, the degree of this influence depending on the form of protective gear. When man wears protective personal resources, he limits the volume of his so-called "subgarment space," as a result of which it becomes difficult to maintain an optimum microclimate and gas composition within this space. The parameters of this microclimate are determined by the products of the body's vital activities (metabolic heat, moisture, anthropotoxins) and by certain foreign substances which may be contributed by the materials from which the personal protective resources are made.

A significant number of works devoted to the influence of low environmental temperatures on the human body have now been published in the Soviet and foreign literature (9,35,66,97,107,110,150,211,303,308,332,341,371,384 etc.).

Unfortunately the problem of man's individual protection against cold was not reflected in these works. In reality, a monograph devoted to this problem and published more than 20 years ago by the Canadian physiologists A. Barton and O. Edkholm (25) is still the principal reference used by specialists working on the theoretical and practical problems of creating individual protection against cold. The present work should be viewed as an attempt to continue and develop these and other studies aimed at providing the physiological and hygienic grounds for personal protective resources.

Monographs published in recent times (13,99,103,144 etc.) are devoted only to particular problems: the planning of clothing for personal use, predicting the thermal status of the body during work in such clothes in different climatic zones of the country and so on.

There can be no doubt that protection against cold requires more than just clothing. This problem is much broader. We need dependable protection of the breathing organs, the face, the limbs (especially when performing delicate manual operations in cold) and so on. When we refer to personal protective resources, we imply special clothing, special footwear, isolating overalls, resources protecting the breathing organs, the head, face, eyes and hearing, and individually employed safety devices.

Because the conditions under which man is subjected to cold and the specific features of each concrete production operation or production situation are so diverse, we cannot provide any all-embracing recommendations. But the basic physiological and hygienic requirements imposed on personal protective resources and on their design, from a medical and a technical standpoint, remain common, and therefore they must be used as the foundation for planning, making and operating such resources in different sectors of industry.

The available scientific literature of Soviet and foreign authors and our own experimental data, acquired with the assistance of modern research methods and resources, permitted us to generalize the results of the work of a large collective of scientists who have conducted research for many years on personal resources against cold for man.

We are convinced that by using physiological and hygienic research as the basis for creating new personal protective resources, we could realistically count on successfully solving any concrete problem connected with maintaining man's thermal homeostasis in extreme conditions.

Problems associated with freezing, hypothermia and adaptation in man are not illuminated in this work.

The author extends his deep gratefulness to S. G. Salivon, A. A. Stikharev, V. I. Makarov, V. A. Ivanov, Yu. M. Levashov, N. F. Gribanova and M. Ya. Romanenko for making it possible to present the results of their research in this work.

Naturally the author will be grateful to all specialists who send their responses and remarks on the content of this book to the publishing house or directly to him.

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REVIEW OF BOOK ON SLEEP AND MOTOR ACTIVITY

Moscow ZHURNAL VYSSHEY NERVNOY DEYATEL'NOSTI IMENI I. P. PAVLOVA in Russian
Vol 31, No 6, Nov-Dec 81 pp 1318-1321

[Review by A. A. Volokhov (deceased) of book "Son i dvigatel'naya aktivnost'" [Sleep and Motor Activity] by I. A. Vakhrameyeva, Izdatel'stvo "Nauka", Leningrad, 1980, 181 pages]

[Text] Thanks to accumulation of new experimental and clinical data on hypnogenic processes, our knowledge about the nature of sleep and its role in adaptive human and animal activity has been considerably enriched and basically altered in the last two decades. The wide use of electroencephalography, neurophysiological and biochemical methods, as well as accurate and continuous recording of motor reactions, has made it possible to single out several of the main stages of sleep and provide comprehensive descriptions thereof. As a result of a multidisciplinary investigation of the waking-sleep cycle, there has been confirmation of the conception of sleep as an active complexly organized process, in which various special structures of subcortical and cortical regions of the brain are involved. This has been supported by advancement of the conception of motor control directed at active restriction of muscle tone and mobility in certain sleep phases. The conception of supraspinal control assumes the existence of specific mechanisms in the higher motor structures of the brain, which are capable of blocking the output of efferent impulsation to effectors, which could lead to prevention of superfluous motor activity at times of absence of consciousness.

However, since the main theses referable to motor control in the sleep process were validated mostly by experiments on animals and only partially by clinical and physiological observations of man, their applicability to man is still unclear in many respects. This requires further research with the use of adequate new methodological approaches, one of which could be the study of formation of sleep stages according to electroencephalographic and motor components, with analysis of underlying neurophysiological mechanisms in ontogenesis of man.

In recent times, such studies of infants were described in works by a number of foreign and Soviet authors. However, with all the comprehensiveness and depth of investigation of the distinctions of different sleep phases in these studies, there was no detailed consideration of the question of initial

organization of the mechanisms of inhibitory control at the active stages of sleep. For this reason, it should be deemed quite timely and important that the monograph of I. A. Vakhrameyeva has been published, as it deals with investigation of the stages of ontogenetic evolution of supraspinal motor control during the sleep cycle of infants.

This book consists of three chapters. The first one deals with a wide range of issues related to investigation of the distinctions and mechanisms of muscle tone and movements at different sleep stages, as well as their electrographic expression in adults. Physiological studies with the use of polygraphic recording of the EEG and distribution of tonus and motor reactions in the sleep-waking cycle led to distinction of five main stages of sleep, among which the stages described with particular detail include the stage of high-amplitude slow sleep (SS) with spindles, deep sleep with many high-amplitude slow waves on the EEG (SS), the REM or paradoxical sleep stage (PS), also referred to as rapid, active desynchronized sleep, with low-voltage activity on the EEG and paroxysmal rapid eye movements. Data are submitted on separation of motor manifestations during sleep into two groups: constantly observed and relatively seldom encountered (chiefly in pathology) motor phenomena, each of which, in turn, is subdivided into different types of tonic and phasic motor reactions, as well as on analysis of EEG patterns in motor structures of the brain, which are based on the hypothesis of summation of postsynaptic somatodendritic potentials in cortical pyramidal neurons.

In this chapter, there is a very interesting critical discussion of data that validate the well-known conception of Pompeano concerning the mechanisms of organization of depression of spinal motor centers during paradoxical sleep. The submitted data on the behavior of monosynaptic and polysynaptic spinal reflexes (tendon, H reflex and others) indicate that suppression of these reflexes during development of sleep is not attributable to elimination of alleviating influences on spinal centers, but specific inhibitory influences from the reticular formation of the brain stem and vestibular complex transmitted over vestibulospinal and reticulospinal pathways. As the sleep stages change, there is redistribution of correlation between excitatory and inhibitory influences on various levels of the reflex system of the spinal cord. During SS, when the flow of excitatory impulsation to motoneurons is drastically reduced, there is virtually no activation of the system of inhibitory influences, whereas onset of PS, conversely, is related to activation of both excitatory and inhibitory systems of motor control.

Analysis of the conception of inhibitory motor control in the light of current views of the genesis of SS indicates that a special role in its genesis belongs to structures of the region of the dorsolateral part of the tegmentum of the pons (Jouvet et al.). Subsequent neurophysiological analysis made by Pompeano et al., Hobson and McCarley et al. led to the conception of a pontine PS generator as a cyclic system, the main element of which is made up of a group of cholinergic and cholinoreactive cells situated in the region of the giant-cell field of the tegmentum (FTG). These cellular structures are capable not only of excitation by exogenous acetylcholine, but self-excitation. However, activation of FTG neurons does not produce direct inhibitory motor control, rather it is mediated by the inhibitory bulbospinal system and vestibular nuclei. At the same time, according to the conception of Pompeano,

the pontine generator is under the inhibitory influence of monoaminergic mechanisms represented by the norepinephrine-containing neurons of the Locus coeruleus complex and serotonin-containing neurons of the nuclei of the raphe system (pons and mesencephalon).

In general, this chapter is not only a necessary and important introduction to the next chapters that deal with ontogenetic aspects of sleep, but has great independent significance; there, the author sheds light with great expertise on many important fundamentals of neurophysiology of sleep that have not been covered in the Soviet literature.

The second chapter sums up the literature and results of the author's own studies of patterns of muscle tone and motor activity of neonates during sleep. In the general description of early motor activity of the newborn, we were impressed by the increased tone of the flexor muscle system and highly generalized motor activity, which subsequently undergo changes that coincide with specific states of the infant during the waking--sleeping cycle. With reference to segmental and supraspinal mechanisms of organizing postural-tonic and motor activity of infants, it is indicated that a conception is formed on the basis of new experimental data on neuronal organization of the segmental system and hierarchic organization of the system for control of movements, according to which the function of controlling motor activity is effected by using spinal systems of interaction of neuronal elements, which are formed on underlying levels. In neonates, the system of supraspinal regulation of the segmental system is organized differently from adults: in early ontogenesis, one can readily elicit numerous spinal reflexes in infants, which are already reduced or have disappeared in adults. Data obtained by the author using electromyographic methods, in particular the H-reflex method, as well as information in the literature concerning morphological development of spinal cord cellular elements, are indicative of the relative functional maturity of the spinal cord reflex system in neonates. Neurophysiological analysis of supraspinal influences in these infants suggests that it is possible for movement to be triggered by the mechanism of autorhythmic activity, in addition to reflex stimulation of sensory systems on the spinal and even higher center levels. However, the last statement should apparently be considered too categorical, since no convincing evidence is offered to validate it, while the isolated case observed by the author of appearance of rhythmic bursts of activity on the EMG of the brachial muscle of an infant (page 58) cannot be given serious attention.

In the next sections of this chapter, there is discussion of the distinctions of onset of sleep processes on the EEG, and according to autonomic and motor parameters. Data are given concernng the substantial differences between sleep stages in adults and infants, in particular, concerning the separation of sleep of neonates into two main stages--"active sleep" (AS) and "calm sleep" (CS), as opposed to slow sleep (SS) and paradoxical sleep (PS) in adults. AS is characterized by low-amplitude, often irregular EEG activity, with rapid eye movements, diminished tone of some muscles, irregular breathing and palpitations, high level of general motor activity, while CS corresponds to high-amplitude slow waves on the EEG, slow irregular breathing and heart beat, accentuated tone of the same muscles, absence of rapid eye movements and

low general motor activity. With reference to inception of the different sleep stages of neonate, premature and mature infants, an effort is made to trace the ontogenetic evolution of the main stages of sleep (AS and CS). It is found that differentiation of these stages with respect to characteristics of respiratory excursions of the chest, EEG patterns and general motor activity begins several weeks prior to normal birth time and by that time there is distinct separation of these two stages. True, we cannot fail to note that the data concerning formation of these processes at different stages have not been sufficiently systematized, and they are fragmentary.

The third chapter is concerned with the solution to the problem raised in the introduction of development of mechanisms of organization of depression of spinal motor centers in human ontogenesis. Using the method of monosynaptic testing of reflex excitability of spinal motoneurons (H-reflex method), in a large series of studies, the author demonstrated age-related distinctions in excitatory and inhibitory supraspinal influences on motor centers of infants (starting in the 28th week of the gestation period up to birth, as well as the first 2-3 months after birth) at different stages of sleep and waking states. To identify the AS and CS phases of sleep, which is particularly important in infants up to the age of 2-3 months, determination was made of the dynamics of various quantitative functional parameters (general and spectral EEG, index of counterphases of respiratory excursions, Hoffmann reflex and others), which permit determination of onset and development of tonic and phasic depression in children differing in physiological maturity. It was demonstrated that the dynamics of H-reflex amplitude in healthy neonates demonstrate a relationship to sleep stage: the H response reaches a maximum during CS, whereas general depression of the H reflex is observed in AS, but such a pattern is not yet seen in premature infants.

As a result of these studies, it was established that there are three stages of ontogenetic development of supraspinal inhibitory mechanisms during sleep at the above-mentioned early stage of ontogenesis, which are formed in the following order: 1) phasic (presynaptic) inhibition; 2) tonic (postsynaptic) γ-inhibition; 3) tonic (postsynaptic) α-inhibition; 4) activation of interneuronal inhibitory system. The presence in neonates of phasic and tonic depression of spinal reflexes during development of AS and enhancement thereof during CS are consistent with one of the important theses in the conception of Pompeano.

While we rate highly the description of ontogenetic stages of development of correlation between sleep processes and motor activity in man, it is regrettable that it pertains to a relatively short prenatal and postnatal period of ontogenesis. Yet it is known that the stage principle of formation of motor functions is also valid in subsequent periods of postnatal life, in particular, the "critical" times of organization of movements observed at an early preschool age, at the age of 7-8 to 11-12 years (period of second childhood) and puberty (14-15 years). Investigation thereof in the aspect of development of stages of depression of supraspinal mechanisms during the sleep cycle is felt to be quite promising to solving the problem of adult sleep.

The data furnished in this book concerning the stages of ontogenetic development of mechanisms of depression of spinal motor centers during sleep at the early stage of human life go beyond the mere establishment of age-related distinctions in formation of these mechanisms, and they have broader implications to disclosure of evolutionary patterns of development of inhibitory processes in general. The author validly discusses this matter in her conclusion, assessing her data in the light of the evolutionary conceptions of L. A. Orbeli about development of inhibitory functions.

On the whole, this monograph, which summarizes the author's data and those in the literature concerning the important problem of correlation between sleep processes and motor functions in ontogenesis of man and sheds light on this problem from the standpoint of evolution, is a valuable scientific work, both theoretically and practically. This book will undoubtedly attract the attention of specialists--biologists, physiologists and micropediatricians.

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REVIEW OF BOOK ON EMOTIONAL MEMORY AND ITS MECHANISMS

Moscow ZHURNAL VYSSHEY NERVNOY DEYATEL'NOSTI IMENI I. P. PAVLOVA in Russian
Vol 31, No 6, Nov-Dec 81 pp 1322-1325

[Review by R. I. Kruglikov of book "Emotsional'naya pamyat' i yeye mekhanizmy" [Emotional Memory and Its Mechanisms] by Ye. A. Gromova, Izdatel'stvo "Nauka", Moscow, 1980, 181 pages]

[Text] Investigation of learning and memory mechanisms has become one of the basic directions of neurobiology in recent years. The advances and achievements in this field are not only of obvious independent importance, but an aid in elucidating the functional patterns of CNS [central nervous system] activity and create realistic conditions for effectively controlling this activity.

The recently published monograph by Ye. A. Gromova, "Emotional Memory and Its Mechanisms," can serve as convincing evidence of the foregoing. This monograph, which summarizes many years of research conducted by the author and the team she heads, deals with the most complex and pressing aspects of the memory problem. The main distinction of the monograph is that the general patterns and mechanisms of learning and memory processes are discussed on the example of one of the forms of mnestic activity, emotional memory. At the same time, it should be stressed that the results of the comprehensive and purposeful investigation of emotional memory and its mechanisms, which are submitted in this monograph, fill the perceptible gap that had existed in the literature on this subject.

The monograph consists of six chapters, which systematically deal with different aspects of emotional memory. Since current conceptions of the essence of learning and memory processes serve as the theoretical premise for investigation of neurophysiological and neurochemical mechanisms of emotional memory, the author justifiably begins the monograph with a description of current conceptions referable to structural and functional organization of memory. The relevant material submitted in Chapter 1 touches upon all of the main directions of research in this field and it is of unquestionable independent significance, constituting an essay of the current status of the memory problem. In this section, the classifications given by the author of different forms of memory and current conceptions of biochemical bases for fixing and retaining information in the CNS merit special attention. Although several major surveys and summaries have been published in recent years on the biochemistry

of learning and memory, because of the good systematization and consistent presentation of her point of view, the material in the first chapter of the monograph dealing with these matters is interesting to read and generally enlarges appreciably theoretical and survey literature. The author quite validly stresses that, with all the profusion of facts about involvement of RNA and proteins in learning and memory processes, no conclusive data have yet been obtained on the coding of individual experience in macromolecules. She advances an original conception of neurotrophic mechanisms of memory on the basis of analysis of the distinctions of neuronal metabolism, and it consists of the following. Upon perception of various stimuli, appropriate electric signals travel to neurons over specific sets of synapses. By virtue of genetically fixed mechanisms, synaptic activation through the system of cyclic nucleotides leads to derepression of specific genes and synthesis of specific proteins. The function of these de novo synthesized proteins is to implement reception of corresponding neuromediator factors. As a result, a given neuron is involved in a system of interrelated neurons. In the light of the conception that the author develops, long-term memory is based on functional interneuronal connections, the nature of which on the level of individual neurons is coded in DNA molecules. In our opinion, this conception merits further development and definition and, in particular, there must be determination of the role of reinforcements and their relationships, primarily time relationships to signaling factors.

The author concludes the essay on the current status of the memory problem by emphasizing very validly that the main task of research on the biochemical bases of memory is to investigate the mechanisms of effects of neuromediators on activity of the neuronal genetic system and processes of intracellular metabolism.

Chapter 2 of the monograph deals with neurophysiological and neurochemical bases of emotions. While analyzing neurophysiological mechanisms of emotions, the author calls attention to the need to answer two basic questions, namely: Is there validity to reduce the entire diversity of emotions to emotionally positive and emotionally negative states, and is it possible for there to be relatively independent mechanisms for each of these states? In the author's opinion, both questions as a whole can be answered in the affirmative. And, since organization of adaptive behavior requires prompt evaluation of the usefulness or harm of a situation, the mechanisms of such evaluation must be inborn. These mechanisms, as they interact with physiological systems of perception of stimuli, impart the appropriate emotional coloration to the perceived situation. The neurochemical basis of emotional reactions is given a large place in the conceptions that the author develops about the nature of these reactions. After comprehensive analysis of an extensive literature, the author concludes that biogenous monoamines are actively involved in organizing emotional behavior. At the same time, the author calls attention to the contradiction of published data, which is indicative of the need for continued special investigation of the differential role of biogenous monoamines in organization of positive and negative emotional reactions.

The role of attention in memory mechanisms is the topic of Chapter 3. Along with data from the literature, it discusses the results of the research

pursued by the author and her coworkers. Proceeding from the general thesis that the state of attention is expressed by changes in evoked potentials, the author investigated the modulating influences of different parts of the hypothalamus on primary responses (PR) of the visual cortex of unanesthetized rabbits. It was found that stimulation of structures of the anterior and posterior hypothalamus affected PR differently. This finding served as the grounds for studying the chemical nature of modulating hypothalamo-cortical influences. The results of these studies led the author to the conclusion that modulating influences of the hypothalamus on perception of sensory stimuli are implemented by monoaminergic systems. This thesis was confirmed in studies using the method of microionophoresis. Taking into consideration data about involvement of monoamines in organization of emotional reactions, these facts enabled the author to advance an interesting conception of participation of monoamines in formation of directed attention which enhances perception by increasing neuronal capacity to isolate a signal from noise.

Chapters 4 and 5 occupy a central place in the monograph, and they deal with the functional link between emotion and memory, and the role of monoaminergic systems of the brain in effecting this link. In a study of memory as a function of level of emotional tension, the author and her colleagues obtained some extremely interesting material, and this was considerably aided by the use of original methods and fortunate choice of subjects (athletes). As shown by the studies, a general (to a specific limit) increase in emotional tension is associated with improvement of short-term memory; conversely, absence of emotional tension worsens short-term memory. The conception ensuing from data of optimum level of emotional tension for mnestic activity was also confirmed in special experiments on humans with the use of a modified method of perceptual conflict. In experiments on animals, the author demonstrated the involvement of different emotiogenic structures of the brain (hypothalamus) in learning and memory processes, and the role of these structures in consolidation processes. Their purposeful and systematic study of the role of monoaminergic systems of the brain in learning and memory processes led the author and her colleagues to the conclusion that activation of serotoninergic mechanisms of the brain improves the learning process with use of emotionally positive (food) reinforcement and worsens learning with the use of emotionally negative (electric, nociceptive) reinforcement. Conversely, activation of catecholaminergic brain mechanisms improves learning with emotionally negative reinforcement and has no appreciable influence on learning with food reinforcement. On the other hand, a decline in functional activity of serotoninergic and catecholaminergic systems also has different effects on development of conditioned food and defense reflexes. In summarizing these data, the author arrives at the basic conclusion that serotoninergic and noradrenergic systems of the brain participate actively in learning processes, and this involvement is effected via the emotional sphere. According to the author's data, the serotoninergic system plays the leading part in organizing emotionally positive behavior, whereas the noradrenergic system of the brain plays such a role in organization of emotionally negative behavior. These conclusions, which are of a basic nature, would gain even more conviction, in our opinion, if a broader set of behavioral tests had been used to substantiate them. The fact of the matter is that the consequences

of interventions in brain activity, including function of neuromediatory systems, are determined not only by the nature of interventions, but distinctions of tests used to demonstrate the consequences of these interventions. In particular, much depends not only on the nature but features of the conditioned reflexes used. We know, for example, that a serotonin deficiency in the brain has different effects on conditioned active and passive avoidance reflexes, although both reflexes are of the same defensive nature. It is also well-known that a shortage of norepinephrine in the brain has different effects on various conditioned food reflexes (for example, running through mazes and depressing a lever).

We cannot fail to agree with the author when she stresses that moderate changes in the physiological range are the most adequate for demonstration of the role of monoaminergic systems of the brain in learning and memory processes. Indeed, rather large doses of monoamine precursors or inhibitors of synthesis thereof are used in many studies. But the use of relatively intensive factors must be viewed as a necessary stage of development of appropriate studies, one of the future objectives of which is to determine the dose functions. In-depth analysis of correlations of monoaminergic systems of the brain according to various functional parameters thereof led the author to conclude that these correlations are reciprocal. This conclusion is one of the major general conclusions in the monograph being reviewed; it not only deepens the conception of the role of monoaminergic neuromediatory systems in brain function, but predetermines to a great extent the direction of future research in this field.

We should like to make special mention of the significance of the final section of the fifth chapter of this monograph, which discusses the prospects of pharmacological influence on memory through metabolism of biogenous monoamines. The author substantiates quite convincingly the possibility of therapeutic use of agents that normalize monoamine metabolism on the basis of the results of in-depth examination and treatment of mentally retarded children who present disturbances in metabolism of biogenous monoamines. The author's indication of the feasibility of predicting the therapeutic effect according to parameters of functional balance of monoaminergic systems also merits much attention.

The final, sixth chapter of the monograph is concerned with comprehensive description of emotional memory proper, principles and methods of producing models thereof. It also discusses in detail the role of the brain's monoaminergic systems in the mechanisms of emotional memory. Among the interesting ideas advanced by the author in this chapter, the explanation she offers for the speed of formation of emotional memory is impressive. Involvement of monoaminergic systems of the brain, which have extensive connections with other parts of the CNS, in mnestic processes provides for immediate interaction of incoming sensory information with inborn forms of emotional behavior. Such interaction is instrumental in faster and lasting fixation of information.

As the author indicates in the "Conclusion," the purpose of this monograph was to call the attention of physiologists, psychologists, clinicians, pharmacologists and specialists in other fields to the need for deeper studies of emotional memory, objective investigation of which is only at its first stage.

There is every reason to maintain that the monograph of Ye. A. Gromova will not only draw the attention of researchers to the problem of emotional memory, but will serve as an important milestone in experimental and theoretical work on this pressing problem. At the same time, the monograph of Ye. A. Gromova makes a substantial contribution to the study of general neurophysiological and neurochemical mechanisms of learning and memory, and it is of considerable and unquestionable interest to specialists working in this area of higher nervous activity.

10,657
CSO: 1840/136

RADIATION BIOLOGY

UDC: 613.647:621.375.826

INDUSTRIAL HYGIENE AND PREVENTION OF OCCUPATIONAL PATHOLOGY RELATED TO WORKING WITH LASERS

Moscow GIGIYENA TRUDA I PROFILAKTIKA PROFPATOLOGII PRI RABOTE S LAZERAMI in Russian 1981 (signed to press 10 Sep 80) pp 2-5, 208

[Annotation, introduction and table of contents from book "Industrial Hygiene and Prevention of Occupational Pathology Related to Working With Lasers", by Vladimir Pavlovich Zhokhov, Angelina Antonovna Komarova, Larisa Ivanovna Maksimova, Vitol'd Rostislavovich Muratov, Yuriy Petrovich Pal'tsev and Anatoliy Ivanovich Semenov, Izdatel'stvo "Meditsina", 991 copies, 208 pages, illustrated]

[Text] This monograph was written by a team of authors working in various scientific institutions. It describes in detail the characteristics of laser radiation fields and measuring methods, gives information about existing measuring equipment; a summary is made of data from the literature concerning the biological effects of laser radiation on animals and man as related to different field characteristics; analysis is made of the possible mechanisms of interaction between radiation and living tissues. Special attention is given to the effects of laser radiation on the eye, as well as integument. Clinical and physiological data are submitted concerning the health status of specialists working with lasers; existing standards are given in the area of evaluating field intensity of laser radiation, which require more definition. This monograph is intended for hygienists, occupational pathologists and specialists concerned with the problem of biological effects of laser radiation and work on protective and preventive measures. There are 17 figures and 6 tables.

Introduction

The constant refinement of technology is a mandatory prerequisite for development of all types of industry. Technological progress alleviates human labor, permits considerable intensification and acceleration of industrial processes; radio-electronics, semiconductors and ultrasound are becoming increasingly prominent in industrial technology. Laser technology is also being developed and refined.

The wide use of lasers in science, technology, medicine and other sectors of the national economy is associated with a considerable increase in number of

people who might be exposed to laser radiation, which is a new factor in the industrial environment. Already in the early years of making practical use of lasers it was established that their radiation could present a hazard to man in some cases. All this makes it necessary to elaborate scientifically validated standards for laser radiation, as well as to implement protective and preventive measures that would rule out the adverse effects of laser radiation on man.

Many works have been published to date, both in the Soviet and foreign literature, that are concerned with different aspects of this problem. Analysis of the literature shows that most studies were conducted in order to determine the therapeutic properties of laser radiation and they are purely qualitative in nature, which is not always acceptable when dealing with hygienic problems, which require determination of the quantitative relationship between intensity of laser radiation and its effects. This is largely attributable to the specifics of the work of clinical physicians, the fact that most modern laser units used for clinical purposes are not equipped to take quantitative measurements, as well as inadequate theoretical basis for metrology of laser radiation.

The first experiments on the effects of laser radiation on living tissue already revealed that it has high biological activity, and many researchers attributed this to the specific properties of laser radiation, particularly its coherence. Yet it is known that there is no one-to-one relationship between coherence of a radiation source and coherence of the radiation field in the place where the irradiated object is located. It is also known that the photometric methods of measuring intensity of electromagnetic radiation fields that are familiar to hygienists and occupational pathologists are not generally suitable for measurement of the characteristics of coherent radiation. All this makes it imperative to undertake theoretical elaboration of the fundamentals of methods for quantitative measurement of intensity of laser radiation, with consideration of its coherence, as well as to determine the range of application of the photometric approach to this problem.

The next tasks are to define the characteristics of the field of laser radiation, which determine to a large extent the biological effect of this field, to refine methods of measuring these characteristics, as well as make the choice of necessary measuring equipment. When this is done, it will be possible, on the one hand, to make quantitative measurements of intensity of laser radiation fields as related to each specific situation and to compare this intensity to the maximum permissible levels (MPL), thereby implementing sanitary and hygienic control. On the other hand, proper formulation and solution of the above problems are mandatory conditions for obtaining scientifically substantiated material to set MPL according to experimental data.

The practical use of lasers makes it imperative to classify known lasers, those under development and laser units according to the nature of effects of their radiation on man, to classify the possible types of illumination from laser radiation, as well as to systematize data on the expected levels of laser field intensity in industry, scientific laboratories, clinical practice, etc.

An entire set of problems must be solved in order to gain the proper idea about the hazard of laser radiation to man. One of these problems is to determine the nature of changes that occur in individuals exposed to laser radiation, as related to characteristics of the laser field, in order to work out appropriate criteria for setting hygienic standards. Since there are substantial legal and ethical restrictions on obtaining such information on man, animal experimentation is the main source of factual material. This generates the specific problem of interspecific extrapolation, which has not yet been definitively resolved.

Unqestionably, there is a difference between the consequences of exposure to laser radiation by chance of man and the long-term exposure that occurs when working with laser installations. Hence the need for a differentiated approach to the choice of factors that have an adverse effect on man, as well as to setting the MPL.

At the present time, standards have been developed and are in wide use, which regulate the MPL of laser radiation, which do not conform, to some extent, to the constantly increasing volume of information about the effects of lasers on the organism. This raises the problem of refining [defining] the standards, as well as widening the range of characteristics of the laser field, for which standards should be set.

It is of great practical interest to consider the ways and means of protection against laser radiation, as well as development of the necessary preventive and therapeutic measures.

This monograph, which is the first attempt in the Soviet literature to summarize material accumulated on this subject, deals expressly with all these questions.

Contents

10,657
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UDC: 577.3

REACTION OF PROLIFERATIVE AND RESTING TUMOR CELLS TO PERIODIC PULSED ULTRAVIOLET LOW-INTENSITY LASER RADIATION

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 262, No 6, Feb 82 (manuscript received 29 Sep 81) pp 1498-1501

[Article by T. I. Karu, G. S. Kalendo, V. S. Letokhov and V. V. Lobko, Scientific Research Center for Technological Lasers, USSR Academy of Sciences; Institute of Spectroscopy, USSR Academy of Sciences, Troitsk, Moscow Oblast; and Oncological Research Center of the USSR Academy of Medical Sciences, Moscow (submitted by Academician A. M. Prokhorov on 1 Sep 81)]

[Text] It was previously demonstrated that powerful pulsed laser radiation of picosecond duration (λ = 266 nm) can have a selective effect on nucleic acids of tumor cells [1]. It was found that, by varying the radiation parameters (number of pulses and their intensity), one can alter the rate of nucleic acid synthesis, accelerating it or slowing it down. It is of great theoretical and practical interest to find out how the same cells would react to UV [ultraviolet] laser radiation at the same wavelength and in the same dosage, but delivered in a different form. As such a source, we chose a source of UV radiation that is new to photobiology, which is based on transformation in the UV range of radiation from pulsed period lasers on Cu dyads [?]. Such a laser emits pulses lasting 18 ns at wavelengths of 510.5 nm and 578.2 nm at a frequency of 10 kHz and mean power of several watts. When these two waves are summated in a nonlinear crystal, one can obtain UV radiation pulses at λ = 271 nm and frequency of 10 kHz, with mean power of up to 10^{-3} W and peak energy of up to 10 W. Unlike the continuous sources of UV radiation that are generally used in photobiology, the effect is pulsed, periodically recurrent in nature. At the same time, the peak energy of the pulses is not sufficient for occurrence of any nonlinear effects in biological molecules of the type observed in [1], so that our first task was to study the photobiological effects of periodic pulsed UV laser radiation and to compare them to the effects of continuous UV radiation from the usual source with the same dosage of radiation, i.e., to check the law of reciprocity.

This study was conducted on a culture of HeLa tumor cells at the logarithmic stage of growth (proliferative cells) or stationary stage of growth (resting cells). Such models were chosen because there are always some cells in the populations (including those of real tumor tissues) that do not participate in proliferation, along with proliferative cells [2]. These so-called resting cells may fail to multiply for an indefinite time and retain their

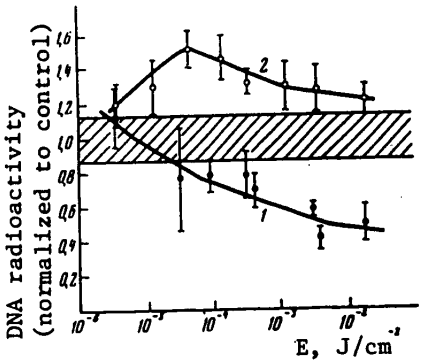

Figure 1.
Change in DNA synthesis (measured in decays/min, with results normalized to the control) after exposure to periodic pulsed laser at λ = 271 nm in resting (1) and proliferative (2) cells

viability entirely. From this state, the cells can return into the cycle under the influence of an adequate stimulus. It is believed that resting cells are much more resistant to deleterious factors that proliferative ones, which is related to the specifics of this physiological state of cells [3]. Bearing this in mind, it is also interesting to compare the behavior of resting and proliferative cells after exposure to lasers. This was the second objective of our study.

The culture was irradiated 72 h after plating, when there were $4\text{-}5\cdot10^5$ cells (proliferative cells) per vial or after 10 days (resting cells) when there were 10^6 cells per vial. The irradiation technique was described in [1]. Radiometry was used to study the intensity of incorporation of labeled precursors of DNA and RNA synthesis (^{3}H-thymidine and ^{14}C-uridine, respectively), permeability of cell membranes for these precursors under normal conditions and after exposure to lasers, adhering to the methods described in [4].

We used a BUF-15 mercury lamp as noncoherent source of UV light (λ = 254 nm), which was focused with a quartz lens at a focal distance of 12 cm. The dose rate constituted 0.06 mW/cm^2 in the plane of the bottom of the vial with cells. A shutter [obturator] was used (10- and 100-fold attenuation) to reduce the mean energy of radiation to the required level.

We tested the effects of the second harmonic of the copper laser (λ = 271 nm) on HeLa cells with change in radiation dosage from $5\cdot10^{-6}$ to $2\cdot10^{-2}$ J/cm^2. Both DNA synthesis and permeability of the cell membrane to the ^{3}H-thymidine precursor of DNA synthesis were found to be sensitive to this type of radiation (Figures 1 and 2). We found that there were opposite reactions by proliferating and resting cells. In the case of proliferative cells, DNA synthesis (Figure 1) was depressed over the entire range of doses we tested, i.e., the larger the dose, the greater the depression of DNA synthesis. There was an analogous reduction in permeability of the cell membrane to ^{3}H-thymidine (Figure 1). In the case of resting cells, we observed an increase in DNA synthesis with the same range of doses (Figure 1), and it reached a maximum with a dosage of $5\cdot10^{-4}$ J/cm^2. With further increase in dosage, the rate of DNA synthesis decreased to the control level. There was concurrent increase in permeability of the cell membrane (Figure 2), with a maximum at approximately the same dosage ($5\cdot10^{-4}$ J/cm^2).

RNA synthesis turned out to be a process with little sensitivity to radiation by the second harmonic of the copper laser at λ = 271 nm, although there is RNA absorption, like DNA, at this wavelength. Incorporation of ^{14}C-uridine

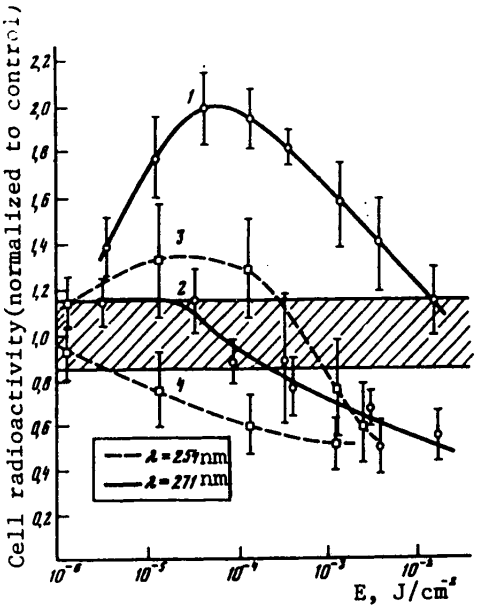

Figure 2.
Change in membrane permeability for ^{3}H-thymidine after exposure to periodic pulsed laser at λ = 271 nm (1--resting cells; 2--proliferating cells) and after exposure to continuous UV light at λ = 254 nm (3--resting cells, 4--proliferating cells)

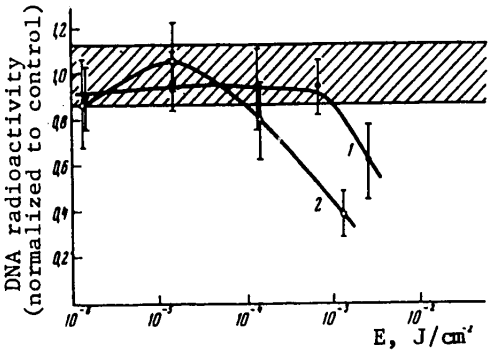

Figure 3.
Change in DNA synthesis after exposure to continuous UV light at λ = 254 nm (1--resting cells, 2--proliferating)

remained at the control level over the entire range of doses (from $5 \cdot 10^{-6}$ to $2 \cdot 10^{-2}$ J/cm^2) in both proliferating and resting cells.

To compare the photobiological effects of periodic pulsed UV radiation to UV radiation from a continuous source, we conducted experiments under exactly the same conditions using low-intensity continuous light (BUF-15 UV lamp). Unfortunately, its maximum radiation (λ = 254 nm) does not coincide exactly with the wavelength of the second harmonic of the copper laser (λ = 271 nm), but this wavelength is still in the range of nucleic acid absorption. As can be seen in Figure 3, the changes in DNA synthesis in proliferative and resting cells under the influence of noncoherent UV light were essentially the same: it remains at the control level with low doses and is depressed with increase in dosage. No stimulation phase is observed. Permeability of the cell membrane for ^{3}H-thymidine diminishes monotonically with increase in radiation dose in the case of proliferating cells, whereas in resting cells, it presents mild (within the range of the error factor) tendency toward increase with low doses, which changes to depression when the dosage is increased (Figure 3).

As we see, the reaction of proliferating cells to radiation is similar for both periodic pulsed and continuous UV light: with increase in dose, DNA synthesis and permeability of the cell membrane to ^{3}H-thymidine decrease. The findings are quite different in the case of resting cells: noticeable dependence of both processes on stimulation dosage with exposure to periodic pulsed source and no stimulation with exposure to UV lamp. Thus, it can be concluded that, aside from the different reactions of resting and proliferative cells to radiation from a periodic pulsed source, resting cells have a specific

response to this type of radiation: DNA synthesis is stimulated and there is increase in membrane permeability to ^{3}H-thymidine.

Unlike the data submitted above, it was possible to stimulate DNA synthesis in proliferating cells by exposing them to powerful ultrashort picosecond pulses [1]. A comparison of the data given here to the results in [1] leads to the conclusion that pulsed radiation in the same dosage but different form (intensity, pulse duration, recurrence frequency) can elicit different responses in cells. Apparently, this is attributable to the fact that in one case [1] there is a two-quantum excitation process and in the other (Cu laser) a single quantum process. This conclusion is also confirmed by the results we obtained here when proliferating cells were exposed to UV light: a decrease in DNA synthesis also dependent on dosage, without stimulation phase. We have yet to determine the mechanism of stimulation of DNA synthesis in resting cells in this light. We can only assume that it is a specific response of resting cells to periodic pulsed irradiation.

Thus, there are three conclusions:

1. Exposure to periodic pulsed lasers at λ = 271 nm elicits a change in DNA synthesis and permeability of cell membranes to ^{3}H-thymidine, the precursor of DNA synthesis, in both proliferating and resting cells. There is a qualitative difference between reactions of resting and proliferating cells.

2. Periodic pulsed laser radiation induces dose-dependent depression of DNA synthesis in proliferating cells. Continuous UV light has an analogous effect on proliferating cells.

3. Periodic pulsed laser radiation induces a dose-dependent stimulation of DNA synthesis and increase in permeability of the cell membrane for ^{3}H-thymidine in resting cells, whereas exposure to the same doses of continuous UV light do not elicit stimulation. Evidently, stimulation of DNA synthesis and increase in permeability of the cell membrane are related to the periodic pulsed nature of radiation.

The authors are grateful to A. N. Zherikhin and V. I. Mishin for their assistance in the work with the Cu laser, as well as to V. A. Semchishen and Ye. V. Yudakhina for help in conducting the experiments.

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10,657
CSO: 1840/194

HUMAN FACTORS

UDC: 658.512.011.56

USE OF DIGITAL COMPUTERS FOR EVALUATION OF OPERATOR OUTPUT

Moscow PRIBORY I SISTEMY UPRAVLENIYA in Russian No 2, Feb 82 pp 8-9

[Article by N. F. Bezhenov, candidate of engineering sciences, V. V. Kuz'mich and P. A. Tonkonogov, engineers: "Use of Digital Computers to Evaluate Operator Throughput"]

[Text] One of the main elements of automated control systems for technological processes (ACS TP) is the operator. A mandatory prerequisite for improving the efficiency of the entire system is to organize effective interaction between the technical part of the system and [human] operator. The important factors in organizing interaction include conformity of throughput of ACS equipment to that of the operator.

The increase in the system's throughput by means of the operator is always minimal. The steps to increase the system's throughput amount to selection of people who are the most capable, training and instruction thereof. To screen operators, one should make an objective experimental evaluation of their output capacity. Output of the operator in ACS refers to the throughput of the sensory input of the operator and speed of information processing. Operator throughput is the reciprocal of the steepness of reaction time to an incoming signal (tag) as a function of amount of information in the communication received: $\lambda = I/T_{П}$, where I is the mean amount of information per tag [sign] of received communication, in bits, and $T_{П}$ is reaction time in seconds.

The operator's reaction is an action that is performed by means of man's "output devices" (speech, movement) and the operator's motor field, which consists of a set of buttons, keys, etc. [1]. Mainly movements are used to transmit commands. Experimental studies of a number of psychologists determined that reaction time $T_{П}$ is a linear function of quantity of information that is average for a received tag [sign], which is a stimulus for the operator to respond [2]. This function is expressed as follows:

$$T_{П} = t_0 + kI \qquad (1)$$

where t_0 is simple reaction time (lag of operator's motor response to a signal that is known in advance but that appears suddenly), k is the steepness of the line characterizing increment of reaction time $T_{П}$ when the amount of information in a communication is increased.

It is believed that the value of the information received will not have an appreciable influence on equation (1). Each individual operator has his "own" inherent values for steepness [gradient?] k and time t_0. They are minimal for the more skillful operators, and can be reduced (within certain limits) by instruction and training. Thus, in the course of instruction, there must be a source of communications that permits immediate [operational] change in amount of information in the communication, in order to check the operator's throughput. It is expedient to use a discrete alphabet of symbols, $a_i (i = \overline{1, m})$, as such a source, each of which is selected for an operator at random with a certain probability $P(a_i)$. Every symbol in the alphabet delivers an average amount of information, which is determined by the well-known equation for source entropy:

$$H(A) = I(A) = -\sum_{i=1}^{m} P(a_i) \log_2 P(a_i).$$

If the alphabet symbols (for example, numerals) have different laws (series) of distribution in each experiment, the mean amount of information carried with each symbol will differ, in particular, it will be maximal with a uniform law of distribution. The more the distribution differs from being uniform, the less information is given by the source to the operator. If symbols a_i of the alphabet are chosen for an operator N times, the time of his reaction to the message is calculated using the formula:

$$T_{\Pi} = \Sigma \Delta t_i / N$$

where $\Sigma \Delta t_i$ is overall reaction time to all symbols presented to the operator in a given test.

The Consul printer, which is the unit of outputting information from the Mir-2 digital computer, is the source of symbols with different laws of distribution that are presented to the operator. Discrete [digital] messages from the source are numerals, 0, 1, 2, ..., 7, printed on paper at random times. Appropriate programs for the Mir-2 computer are used to generate pseudorandom numbers that form an entire group of events.

Four experiments with the computer are run to determine function $T_{\Pi} = f(I)$. The series of distribution of pseudorandom numbers are approximated by the laws of Rayleigh, normal, exponential and uniform distribution. The distribution series and corresponding amounts of information per symbol are listed in Table 1.

The operator's reaction time is found by measuring the interval between his response [action] and time of delivery of a stimulus (printed digit). The responsive (controlling) action of the operator is to depress a key on the control console, the number of which corresponds to the digit printed by the Consul. The time interval is measured by electronic computation. The times at which the computer prints out the digital symbol and the appropriate

button is depressed determine the leading edge [front] and cut-off [decay] of the gate [strobe] pulse, the duration of which, τ_{str}, equals the measured interval Δt. This time is measured by counting the pulses with fixed recurrence frequency F_c that fill the interval. If the recurrence frequency of counting [calculating?] pulses equals F_c (recurrence period T_c) there will be $C = \Delta t/T_c = \Delta t F_c$ within the measured interval Δt.

Table 1.

Approximating law of distribution	Symbols 0	1	2	3	4	5	6	7	bit/symbol
Rayleigh	0,01	0,17	0,41	0,275	0,055	0,035	0,025	0,02	1,7
Normal	0,025	0,05	0,17	0,255	0,255	0,17	0,05	0,025	2,37
Exponential	0,22	0,19	0,15	0,12	0,09	0,08	0,078	0,072	2,88
Uniform	0,125	0,125	0,125	0,125	0,125	0,125	0,125	0,125	3

Table 2.

operator	T_{n1}	T_{n2}	T_{n3}	T_{n4}
1	1,12	1,21	1,19	1,291
2	1,203	1,24	1,29	1,425
3	1,02	0,983	1,001	1,2

Table 3.

operator	t_0	k
1	0,912	0,117
2	0,973	0,128
3	0,795	0,103

Thus, the measured interval will be found in the following manner: $\Delta t = C/F_c$ s. The number C of counting pulses that fill the gate pulse is read by the pulse counter, and the frequency meter is used in the summation mode for this purpose.

The experimental equipment for operator training consists of the following (Figure 1): source of communications, interval timer, operator's console with control unit. The Ch3-38 frequency meter (in summation mode), combined with a G5-15 counting pulse generator, is used to measure the time intervals. The generator delivers counting pulses at a fixed recurrence frequency to the input of the frequency meter. The unit that controls the interval timer causes formation of gate pulses and controls delivery of counting pulses to the frequency meter.

The control unit consists of a set of triggers, OR and AND circuits (Figure 2). The triggers are actuated by computer signals that control digital printout. The triggers are returned to their initial (zero) state by the operator, by depressing a button on the working console that corresponds to the digital symbol printed on paper. The gate pulses thus formed pass from the trigger outputs through the OR circuit to the input of the AND circuit, thus causing delivery of counting pulses to the frequency meter input. If the wrong button is depressed in error, one that does not correspond to the printed symbol, the cut-off of the gate pulse is not formed and the frequency meter continues to measure the time interval. Steepness k of inclination [see formula (1)] and the operator's simple reaction time t_0 are determined by

processing experimental data with the least squares method. This provides for best conformity of experimentally obtained results with the individual capacities of operators.

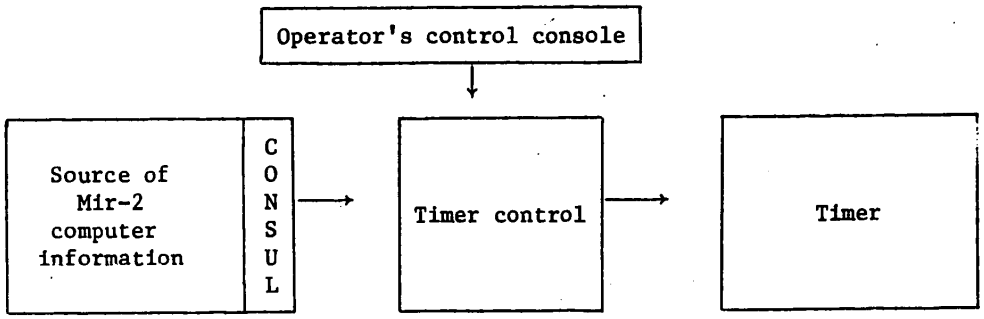

Figure 1.

The experimental values of parameters $T_{пi}$ and I_i, found by the method of least squares are substituted in the analytical expression of the sought function (1); This yields the following system of arbitrary linear equations [3]:

$$\begin{aligned} t_0+kI_1-T_{п1}&=0;\\ t_0+kI_2-T_{п2}&=0;\\ t_0+kI_3-T_{п3}&=0;\\ t_0+kI_4-T_{п4}&=0. \end{aligned}$$

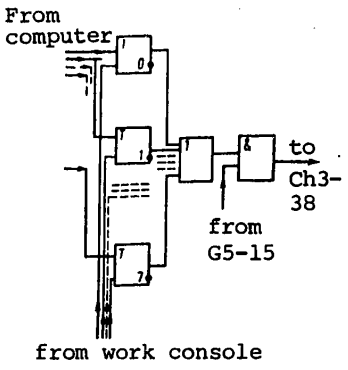

Figure 2.

This system is reduced to normal equations of the following appearance:

$$\left.\begin{aligned} [AA]t_0+[AI]k-[AT_п]&=0;\\ [AI]t_0+[II]k-[IT_п]&=0, \end{aligned}\right\} \qquad (2)$$

where $A_i = 1$ is the coefficient with time t_0.

[AA], [AI], ..., [IT] are found from the experimental data in the following manner:

$$\begin{aligned} [AA]&=A_1A_1+A_2A_2+A_3A_3+A_4A_4;\\ [AI]&=A_1I_1+A_2I_2+A_3I_3+A_4I_4;\\ [AT_п]&=A_1T_{п1}+A_2T_{п2}+A_3T_{п3}+A_4T_{п4};\\ [II]&=I_1I_1+I_2I_2+I_3I_3+I_4I_4;\\ [IT_п]&=I_1T_{п1}+I_2T_{п2}+I_3T_{п3}+I_4T_{п4}. \end{aligned}$$

The values of parameters k and t_0 for each operator are found by solving system of equations (2).

In an experimental test of this method, laboratory technicians and computer laboratory engineers, who had experience in working at the consoles of various digital computers, participated as operators. There were more than 15 tested operators in all. The results of the experiment (reaction time $T_П$ in seconds) were different for each participant. Table 2 lists data obtained for three operators.

After substituting the values of parameters I and $T_П$ in (2) and solving the system of equations on a digital computer, we found the values for time t_0 in seconds and steepness k in s/bits (Table 3).

These values could also be found by graphic plotting (approximately). Experimental determination of time $T_П$ and calculation of time t_0 and steepness k make it possible to assess the individual capacities of an operator (the lower the values of parameters t_0 and k, the greater his throughput capacity).

Throughput of the above-mentioned operators constituted 8.55, 7.81 and 9.71 bit/s, respectively. For other operators who participated in the experiment, there was a 1-1.5 bit/s difference from the above figures for their throughput. This is consistent with the already known results of other experiments, which confirm that man is capable of receiving and processing 0.1-10 bits of information per second [4-6]. Each subject should first become familiar with the experimental operator console to improve the reliability of results.

Thus, use of a digital computer as the source of random symbols delivered to an operator and electronic timing of his reaction to symbols permits immediate ["operational"] evaluation of operators' throughput. This method could be used for screening operators for ACS TP.

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USE OF PHYSIOLOGICAL INFORMATION IN MAN-MACHINE SYSTEMS

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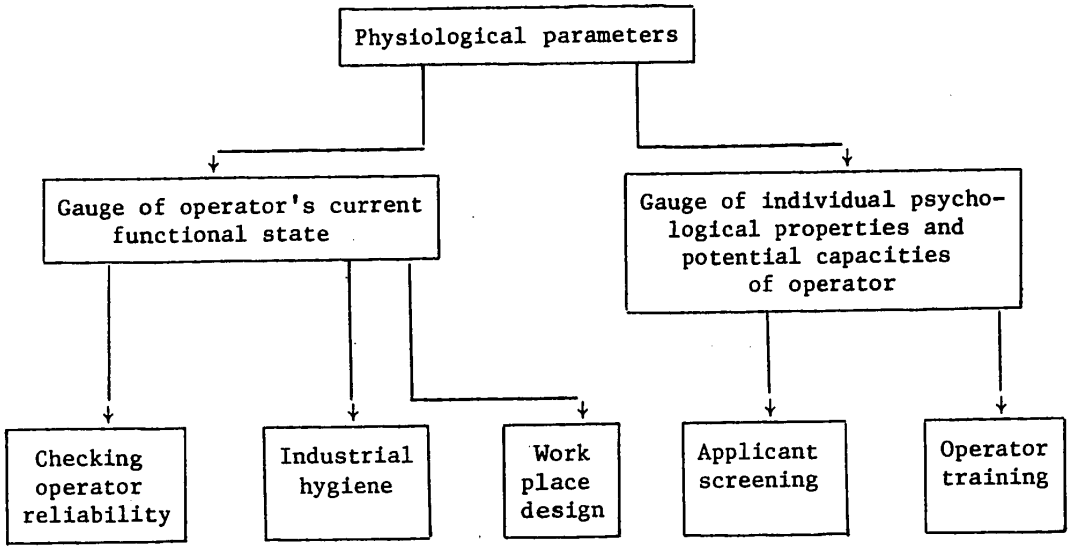
[Text] Use of physiological information about the state and qualities of an operator is discussed in the areas of design, study and operation of man-machine systems. Groups of specialized criteria referable to engineering psychology, which characterize practical tasks, are singled out. The main phases of the methodological approach to construction of formalized assessments of physiological information are developed and described. An approach is offered to construction of a quantitative evaluation of an operator's functional state, which is developed on the example of formation of the scale of operating [working] tension.

In recent times, increasing attention has been devoted to use of physiological information (PI) characterizing a human operator (O) in the design, study and operation of man-machine (MM) systems. Such information is based on measurement of different physiological parameters (PP), such as electrical activity of the brain, cardiac activity, galvanic skin response, respiration, blood and urine biochemistry, and many others.

From the standpoint of problems of engineering psychology, PI can be useful as a gauge of two main factors: current functional state of the operator, for example, degree of fatigue, emotional and working tension, stress, level of wakefulness, etc.; individual psychological traits and potential capacities of the operator.

Evaluation of these factors is very important to many practical tasks where the results can be used for different purposes (Chart). Thus, evaluation of an operator's current functional state is necessary primarily for tasks involved in assuring reliability and efficiency of MM systems, in designing operator work places and problems of industrial hygiene. Evaluation of individual psychological human traits is used in the areas of vocational screening and operator training.



The main stages in solving the problem of practical use of PI in MM systems are: elaboration of an engineering psychological criterion (for example, probability of operator error, probability of worsening of health, degree of change in functional state, etc.) characterizing the practical problem to be solved, which is a function of the measured physiological parameters; determination of the most informative set of PP; development of a formalized method for evaluating the selected criterion in the function of measured PP.

Our objective here was to discuss a range of questions related with the first and third of the above stages. We intend to provide a systematized survey of practical tasks, for the performance of which PI are used, determine the main criteria specific to these tasks, shed light on approaches to development of formalized methods of using PI in current use, as well as to show the way to further refine these methods.

We shall not discuss here questions related to investigation of the informativeness of different PP. This is a problem of great independent importance and requires special consideration. One can find the most complete bibliography on this subject in [7, 9, 60, 73, 78, 80].

I. Areas of Use of PI in Man-Machine Systems

At the present time, the task of developing reliable and refined methods of using PI for practical purposes is at its first stage. However, there have been very many studies directed at development of such methods. Analysis of this research enables us to single out the main promising areas and aspects of using PI.

1. Checking Reliability of Operator Performance

Problems of this class are referable, first of all, to systems, in which emergency situations are possible due to partial or total loss of operator work capacity. These tasks are inherent in, for example, such sectors as cosmonautics, aviation, railroad and motor vehicle transport.

Several works have dealt with general formulation of the problem of using PI to evaluate reliability and efficiency of operator performance [10, 18, 32, 50, 59, 98, 68, 81, 105]. There, stress is placed on demonstration of relationships between changes in PP and decreased operator work capacity [50, 68], determination of permissible range of changes in parameters of physiological systems [10, 18], feasibility of forecasting operator states [59, 10, 94] and several other problems.

One usually makes a distinction in the problem of enhancing operator reliability between such tasks as preliminary checking of operator readiness [qualifications?] for a given job [45, 85], ongoing monitoring of the operator's functional state, which changes under the influence of working and ambient conditions, including extreme factors [44, 75, 78, 115]; implementation of prognostic checks of operator work capacity so that preventive and protective steps can be promptly instituted [10, 41, 71, 89].

Among the most constructive steps referable to monitoring operator reliability, we can list differentiation between active waking and drowsy states according to electroencephalograph (EEG) parameters [2, 25] and galvanic skin response (GSR) [46, 113], assessment of degree of fatigue according to a set of parameters, including the EEG, EMG (electromyogram) and GSR [82], assessment of fatigue according to statistical characteristics of cardiac rhythm [13, 53, 77], forecasting a comatose state according to changes in shape of pulse wave [54], differentiation between rest and activity according to cardiac rhythm [8] and a number of others.

2. Evaluation of Professional Aptitude of Operators

Problems of this type are most often solved as they apply to screening specialists in such important occupations as pilots, railroad engineers, operators of complex technological systems, etc. Psychophysiological studies are pursued in order to screen applicants that meet specific requirements for a given type of work [3, 12, 33, 45]. Use of physiological information in such tasks is validated, first of all, by the fact that there is a correlation between PP and a number of human psychological traits that are significant from the standpoint of professional aptitude [suitability]. Thus, we can mention such experimental data as presence of correlation between level of intelligence and frequency range of evoked potentials [101], between level of vestibular stability and parameters of base tonus of the autonomic nervous system [6], between EMG changes during performance of perceptual tasks dealing with discrimination and psychological ratings on the Eysenck scale [106], between degree of depression of alpha rhythm with a load and level of capacities [102], etc. The existence of such correlations makes it possible to use PP in classifying subjects into groups according to type of nervous system and type of physiological reactions [4, 15, 42, 76, 90, 92, 114, 122], as well as

for assessment of the following: subjects' resistance to extreme factors, for example, vibration, accelerations, orthostatic load, exercise [6, 56, 79], level of mental [101, 102, 103, 119] and operating [93, 104] capacities, suggestibility [69], degree of conditioning [11, 99], etc.

In addition to the above aspects of using physiological information in the area of professional aptitude, we can mention another special area of application [37]. It is known that test study procedures are used extensively in problems of professional screening, which are aimed at demonstrating traits that are professionally important, such as stability and ability to switch attention, operative memory, sensorimotor coordination and a number of others. Measurement of PP which are, in turn, a reflection of an operator's functional state, could be aimed at refining testing methods. Information about such aspects of functional state as degree of operating and emotional tension, degree of fatigue, could be useful in conducting tests in the aspects described below.

The existing methods of assessing testing results (usually problem solving time and number of errors) are rather poor. Information about the subject's state, particularly about his operating tension, could serve as an additional assessment of quality of performance of a given test and, consequently, as an additional evaluation of the tested psychophysiological property. As a result, there is better reliability of testing as a whole, and it also becomes possible to have a more differentiated gradation of the evaluation.

The ratings used in testing are related not only to the tested psychophysiological property but, to some degree, the subject's functional state (emotional excitement, fatigue). Information about this state can be used to either control the testing process (control of testing may consist of taking steps to diminish emotional excitement, stopping the test if there is an inadmissible degree of fatigue, etc.) or to correct testing grades.

The above aspects of using information about the functional state of operators require, in most cases, both qualitative and quantitative evaluation of such states.

3. Operator Training

At the present time, physiological information is used relatively little in tasks of this type. However, it is stressed in a number of works that use of such information is important [22, 45, 59, 63, 70, 72, 84, 96]. Mention is made of such purposes for its use as investigation of the learning process and development of its bases [59, 72, 70, 84], forecasting quality of training [22, 63], development of training equipment [59], etc.

This aspect of using PP is based on the relationship between degree of operator training and degree of his tension, which emerges as a sort of "physiological payment" for the work results achieved. Many studies [70, 100, 110, 121] are aimed at studying the relationships between PP and difficulty of an assignment. Work difficulty is determined by either objective indicators of difficulty of an assignment [57, 121] or duration of training to perform a given job [70].

The results of such studies can be used directly in operator training, both to work out criteria of training and to refine training systems.

In addition, in training problems, information about the operator's functional state can emerge as one of the criteria of causes of nonachievement in the learning process. Excitement, stress, fatigue, weak activity, etc., may be such causes. Depending on the demonstrated cause, one can add some stimulating factors to the training system (incentives, assurance, etc.) in the form of appropriate instructions to the trainee. It is believed that the use of physiological information is particularly promising in development of automated teaching systems.

4. Industrial Hygiene

Problems of this type are aimed at assessing the psychophysiological expenditures of workers in different occupations for the purpose of scientific organization of labor and providing conditions that conform to public health requirements [43, 51].

Studies aimed at solving this problem are pursued during actual work and deal most often with such specialists as pilots [39, 40, 48, 123], air traffic controllers [115, 116], railroad dispatchers [64], computer center workers [17, 77], motor vehicle drivers [16], mine workers [13], etc. Most often, the objective of these studies is to assess man's physiological reactions in the presence of neuroemotional tension [39, 40], stress occurring in emergency situations [48, 115], physical loads [11, 35, 95] and fatigue [13, 16, 77, 82]. Several studies have been made of the effects of such working conditions as monotony [82], holding a strained position for a long time [49], and studies are also made of the dynamics of the state in the course of a work day and week [17]. Many works deal with assessment of the effects of extreme environmental factors, particularly spaceflight factors, on changes in operator PP [9, 18, 78, 89]. The results of the above-mentioned studies can be used directly to form criteria characterizing the effects of work factors on operators' health status.

5. Designing the Operator's Work Place

The problem of using physiological information in problems of operator work place design was raised in several works [5, 21, 34, 67, 72, 118, 124]. In such problems, measurement of physiological parameters permits determination of the relationship between quality of equipment and psychophysiological input required to perform a given job. We can mention a number of studies dealing with consideration of PI in elaborating criteria of quality of information display systems [1, 38, 67], selecting optimum configuration of operator chairs [124], evaluating difficulty in driving motor vehicles with different types of transmissions [118], etc.

There are two main aspects to the practical use of PI in designing problems. In the first place, this information permits direct assessment of designed systems from the standpoint of meeting industrial hygiene requirements and, in the second place, it can serve as an indirect indicator of reliability of operator performance. Both factors determine to a substantial degree the quality of the proposed operator work place.

Evaluation of a proposed system according to the criterion of reliability of operator performance is based on the correlation between psychophysiological input of the operator and difficulty of his work. By estimating the operator's psychophysiological input [expenditure] (on the basis of measurement of PP), one can predict the probability of errors and thereby assess the proposed system. There are several works [57, 70] that deal with evaluation of PP as a function of difficulty of an assignment. These results can be used directly to form criteria characterizing the quality of a proposed system.

By virtue of the prognostic nature of this information, use of PI in this aspect is particularly promising with respect to reducing the time of field [on the job] trials of newly designed systems.

II. Methods of Formalizing PI Evaluations

At the present time, most studies in the area of using PI are chiefly pursued to gain knowledge, and they are directed at demonstration of various physiological parameters as functions (Φ) of some objective indicators or other, which emerge as engineering psychological criteria (W) specific to a given study. This is a so-called "direct" problem whose purpose is to find the functions:

$$\Phi_i = F_i(W),\ i=1, 2, \ldots, n, \tag{1}$$

where n is the number of physiological parameters.

The results of solving this type of problem are reflected in many works [26, 60, 73, 80, 82, 66].

However, to make practical use of PI, one must solve the "opposite" problem, whose purpose is to construct a solving rule that permits evaluation of the adopted criterion W as a function of a set of measured PP:

$$W = \Psi(\Phi_1, \Phi_2, \ldots, \Phi_n). \tag{2}$$

The solutions of these "direct" and "opposite" problems do not ensue directly from one another, due to the heterogeneity of changes in each PP individually as a function of the given criteria and influence of many factors on the nature of these functions. Although most current works deal with investigation of the "direct" problem, it is still far from having been completely solved. There are appreciably fewer studies dealing with the "opposite" problem, and its solution is still far from complete. In this part of our work, our purpose was to discuss the existing approaches to solving the "opposite" problem.

Methodologically, construction of function (2) amounts to proceeding through the following main stages: elaboration of criterion W in terms of the meaningful substance of the practical task to be performed; determination of the aggregate of informative physiological parameters; choice of software that would permit construction of the solving rule to assess the adopted criterion as a function of measured PP.

Let us consider the specifics of these stages in greater detail.

The above survey of practical problems, for the solution of which PI is used, enables us to single out the following main groups of specialized criteria: criteria characterizing operator work capacity in a specified type of work expressed in terms of results of such work. Use of these criteria is made primarily in the area of improving reliability and efficiency of MM systems and design thereof; criteria characterizing the concrete psychological traits of the operator (for example, type of nervous system, intelligence, suggestibility, etc.) expressed in terms of the corresponding psychological properties. Such criteria are used in professional screening and training; criteria that characterize the effects of working and ambient conditions on health. These criteria are used in problems of industrial hygiene, designing MM systems, as well as problems of improving reliability of MM systems.

Apparently, within each of these groups there can be quite a few narrowly specialized criteria determined by the specifics of a concrete practical task. In order to obtain maximum accuracy in solving this problem, it is desirable to form as many specialized criteria as possible. However, such an "individual" approach is justified only for particularly important practical tasks. To make broader use of PI, it is desirable to form a perhaps less accurate but more general criterion, which could be used in various practical problems. The functional state of the operator could serve as such a criterion, for example, degree of fatigue, emotional or operating tension, activation, etc. However, the absence of a strict, formal definition of the concept of "functional state," for which reason it is necessary to select several objective indicators, in the terms of which this concept can be expressed, is a considerable difficulty in the path of forming such a criterion.

Let us consider the existing approaches to methods of specifying the functional state of an operator, which are used in experimental research. Here, we can single out two main directions. The first one involves specification of functional state by means of organizing the experiment. Thus, most often the subject's functional state is given by such procedures as use of emotiogenic stimuli [14, 20, 42, 86, 87, 111], presenting tasks eliciting mental or operating tension [4, 19, 30, 58, 73, 100, 106, 114, 120], use of interference while performing a specified job [57], giving physical loads [11, 91], etc. In such experiments, the functional state is controlled, for example, by changing the difficulty of problems or operations, changing the noise level, setting time limits, etc. Occasionally, such artificial methods as dramatic ["actor"] simulation [73], hypnosis [31, 73] and pharmacological agents [88] are used to produce the appropriate functional state.

The above methods of producing a functional state are referable to model experiments. In addition, experiments are performed rather frequently under real working conditions [16, 64, 115, 107, 117]. In this case, the nature and level of functional state are determined by such factors as work time, presence of emotional factors (passing tests, complicated situation) and a number of others.

With the second approach to means of setting the functional state, indicators of results of performance are used as a criterion thereof [29, 53, 68, 93, 100]. During the experiment, the subject performs a certain work (for example,

working at a bench, solving test problems, etc.), the results of which are evaluated by several objective indicators (number of errors, solving time, etc.). Determination is made of the measured PP as a function of objective indicators of achievement. The latter emerge as a criterion of the subject's functional state.

As for the choice of a set of informative tags, the physiological signs known to date can be divided into the following groups: parametric signs, for example, pulse rate as a correlate of mental tension [73, 40, 20], amplitude of EKG waves as a correlate of mental work [19], arterial pressure as a correlate of operating tension [57, 72], etc.; signs determined by the degree of correlation either between different derivations of physiological signals, for example, change in degree of correlation between bioelectric potentials of different parts of the cerebral cortex during mental work [58], or between different types of physiological signals such as, for example, change in correlations between EKG parameters, pressure and pulse in the presence of fatigue [16]; signs that are determined by the statistical parameters of physiological processes, such as change in spectral and correlation characteristics of R-R intervals of the EKG in the presence of fatigue [13, 10, 53, 77], change in mean asymmetry of duration of phases of alpha rhythm in the presence of a mental load, fatigue and sleepiness [2, 25], etc.

The choice of basic set of signs to construct function (2) is usually made on the basis of prevailing conceptions of informativeness of certain PP or other, as well as the researcher's available technical resources. There is often the problem of minimizing the sign space on the basis of using correlation or factor analysis. The effectiveness of these methods in reducing the number of measured signs is reflected in a number of works [3, 97, 109, 112, 47]. For example, data are furnished that were obtained on the basis of the method of main components to reduce the number of informative tags (EEG parameters) characterizing different types of rest, ranging from several tens to several units [97, 112]. Factor analysis on the basis of examining the time series of R-R intervals of the EKG revealed one informative tag that characterizes pilot tension during flights [47].

The next stage following the choice of the initial set of informative tags is to construct the solving rule to assess the adopted criterion as a function of measured PP. For this purpose, two mathematical approaches are being used: pattern recognition method and regression analysis method. The main distinction of these methods is that the use of recognition actually solves the problem of qualitative evaluation of the criterion under study (most often, determination of its alternate class, for example, sleep--wakefulness, excitement--rest, etc.), whereas with the regression model a quantitative evaluation of this criterion is made on a continuous scale, calibrated in terms of the corresponding objective parameters.

In the area under discussion, the pattern recognition method has the most application, and this is due primarily to the fact that it is less difficult to construct a classification algorithm. As a rule, the recognition method is used to assess the current state of an operator [26, 28, 36, 55, 61, 83, 112] and in professional screening [23, 24, 69, 79]. In most cases, recognition

involves two alternatives. In the first of the above tasks, distinction is made between such states as rest and activity [83], normal and comatose state [54], wakefulness and sleepiness [26], rest [calm] and emotional excitement [20, 61]. In the area of applicant screening, a distinction is made between "good" and "bad" operators [24], those with and without aptitude for learning [23], resistant and nonresistant to suggestion [69], etc. In a number of works, a more difficult problem is solved, namely, recognition involving multiple alternatives [112, 28]. For example, there is examination of the possibility of distinguishing between such states as activity, operative rest, drowsiness, sleep [28]. As a rule, the classification algorithm is constructed by the method of learning with a "teacher." Here, the following two methods of presenting the teaching sample are used. With the first one, the teaching sample is formed by means of obvious specification of identified classes, for example, specifying such states as sleep, drowsiness, rest, or certain types of subjects. Not infrequently, ancillary criteria are also used, which characterize the relevant classes.

With the second method, there is indirect presentation of the teaching sample, which is based on the method of setting up the experiment. Thus, various types of mental activity [26], various types of emotionally significant factors [61], various psychological tests [83], etc., are given by means of experimental conditions. In this case, the specific difficulty of the studies is that the teaching sample is not precisely specified. For example, giving emotionally significant factors cannot always unequivocally determine the subject's emotional reaction. This makes it necessary to increase substantially the size of the teaching sample to assure statistically reliable results.

When constructing the solving rule for recognition of psychophysiological states and operator traits, the basis is quite often referable to experimental data on the properties of the used tags. Most often, one uses the procedure of successive analysis of probabilities that a given tag belongs to a given class [24, 26-28, 69]. This classification method is the most suitable in cases where the recognition process implies the use of additional tag analysis as the diagnostic solution is obtained. This usually occurs in problems of professional screening or identification of developing states, such as sleepiness, fatigue, etc. For example, successive analysis is used [26] to make a distinction between waking and sleepy states on the basis of the parameter that is defined by the mean asymmetry of duration of phases of EEG alpha rhythm. Elsewhere [24], determination was made of whether operators belong to a known good or bad class on the basis of results of psychological tests and physiological reactions. In [69], specialists were screened, who must make important decisions, according to suggestibility on the basis of measurement of a set of EKG parameters.

In several other works [20, 74, 83], a linear discriminant function, the value of which characterizes the degree to which an object with given value of tags belongs to the relevant class, is used for classification of states under study. For example, this method was used to distinguish between rest and emotional tension due to anticipation of an impact load, on the basis of a set of signs such as pulse rate and arterial pressure [20]. A classification algorithm was constructed [83] for the states of calm wakefulness and tension due to performance of test assignemnts, on the basis of measuring the spectral characteristics of the EKG.

This method of classification is the most effective when there is normal distribution of the tags used.

Use of multiple regression analysis is another approach to formalized evaluation of engineering psychological criteria as a function of measured PP [6, 108, 22, 52, 62, 65, 79, 89, 118]. As we have already mentioned, unlike recognition methods, in this case it is a problem of quantitative, rather than qualitative, evaluation. This makes it necessary to use appropriate metrics ("scales") characterizing the adopted criterion in given units of measurement. The appropriate scales are usually formed with consideration of the specific function of the practical task. For example, we can mention studies dealing with evaluation of vestibular stability of subjects [6, 79], forecasting operative work capacity [52], evaluation of quality of flight training [22, 62], etc. In all cases, the problem of forming the appropriate scale amounts to experimental determination of the set of measured PP as a function (2) of the adopted W criterion. For example, flight achievement expressed as a grade [22], quality of performance in units of precision and time characteristics [52], etc., are used as W criteria.

The method of forming function (2) consists of two successive stages: choice of structure of equation accurate to a certain number of unknown coefficients and estimation of these coefficients on the basis of available experimental data. Selection of the structure of a regression equation, is generally limited to construction of linear models of both the unknown coefficients and measured parameters Φ_i. Calculation of the sought criterion is made in the following form:

$$W=\tilde{b}_0+\tilde{b}_1\Phi_1+\tilde{b}_2\Phi_2+\ldots+\tilde{b}_n\Phi_n, \qquad (3)$$

where $\tilde{b}_0$, $\tilde{b}_i$ (i = 1, ..., n) are estimates of coefficients of the regression equation. These coefficients are determined at the stage of "teaching" the model, in the course of which the values of criterion W_j are given (or measured) and the corresponding values of Φ_i are measured. It is assumed that these values are related in equations of the following type:

$$W_j=b_0+\sum_{i=1}^{n} b_i\Phi_{i,j}+\varphi_j, \quad j=1,2,\ldots,N, \qquad (4)$$

where W_j is the value of the criterion in the jth experiment; $\Phi_{i,j}$ is the value of the ith parameter in the jth experiment; ϕ_j is a random centered function which is independent of W_j and determined by the influence of unknown factors on the measurement process; N is the number of equations.

Estimation of unknown coefficients b_i is made by means of the least squares method. The influence of interference is suppressed due to redundancy of the system of experimental cases ["observations"] (N>n).

The effectiveness of using regression models depends largely on the adequacy of conditions of the "teaching" experiment to actual conditions, for which the

scale is being formed. Consequently, the task of providing conformity of "teaching" and "examination" [test] conditions is of first and foremost importance. Although there are few works dealing with construction of regression models, it is evident that this direction is promising from the positive results of a number of studies [22, 52].

III. Means of Further Development of Methods for Formalized Use of Physiological Information

There are mainly two reasons for the difficulty in using PI to solve practical problems. The first is attributable to the complexity of physiological signals notable for such properties as time variability, similarity of reactions to different factors, poor differentiation with regard to different states of the body and very marked individuality. The second reason that makes it quite difficult for practical use of PI is the wide diversity of engineering psychological criteria (EPC), that are specific to each concrete form of activity. Since it is inexpedient to elaborate formalized methods of using PI separately for each type of activity, it is necessary to form a rather general [universal] EPC that is suitable for solving many practical problems.

In this part of our work, we shall discuss one of the possible approaches to solving such problems.

As we have already stated, the most general EPC is evaluation of the operator's functional state. However, the absence of a formal definition of this concept makes it necessary to choose certain objective parameters, in the terms of which it can be measured. In a rather general case, one can select the indicators of operator achievement as such objective parameters. However, the difficulty then arises that the parameters of performance are just as diverse as the types of activity themselves. For this reason, such parameters must be selected in a rather abstract form.

In view of the foregoing, we propose the following approach to creation of a quantitative evaluation ("scale") of functional state on the example of developing the scale of operating tension.

1. A certain set of "standard" problems is selected, each of which is characterized by the specificity of psychophysiological input to solve them. These may be problems that are related, for example, to intellectual or sensorimotor activity, etc. Each of these standard problems is used to form the scale of tension inherent in the corresponding type of activity (intellectual, sensorimotor, etc.).

One must take into consideration the following requirements in selecting a standard problem [or task].

The standard problem must have objective parameters of results of solving it. This may be either parameters of solution quality (number of errors, solving time, etc.) or objective indicators of difficulty of solution (level of interference, limited time, etc.).

Variation of conditions of presentation of the standard problem (for example, variation of pace or duration of presentation, interference level, etc.) should lead to a change in difficulty of solving it, which causes a change in tension.

2. A certain set of physiological parameters is selected, which emerge as informative signs of operating tension. The scale of functional states is formed as physiological parameters as a statistical function of quantitative indicators of results of solving the standard problem.

3. Evaluation of an operator's functional state under real conditions, which is done by measuring his physiological parameters, is made in terms of indicators of achievement in solving the relevant standard problem. For each concrete, real activity a set of standard problems is chosen which corresponds the closest to the job with regard to nature of psychophysiological input required.

The method of constructing a functional state scale consists of the following. A standard problem and method of varying operating tension during solution thereof are selected. For example, tension can be varied by introducing different levels of interference, time limits, modifying the standard problem, etc. This method of varying operating tension is based on the assumption that an operator can sustain the quality of standard problem solving on a constant and rather high level with change in objective difficulty of this problem due to a corresponding increase in tension.

The statistical relationship between the measured PP and objective indicators of difficulty of solving the problem, which are set by the experimental conditions, is determined experimentally for a rather large group of subjects in the course of solving the standard problem. The difficulty of the assignment for each subject is varied in the range of minimum difficulty to a certain critical difficulty, with which accuracy of performance exceeds the permissible range. The objective indicator of problem difficulty corresponding to the critical value is taken as 100% tension, while the corresponding values of physiological parameters expressed in relative amounts of background values are taken as the cut-off values on the formed scale. Thus, as a result of experimenting with each subject, we obtain his physiological parameters as a function of problem difficulty, which is expressed as a percentage of critical difficulty.

This experiment is conducted on a rather large group of subjects, and the individual results are appropriately averaged for the entire group.

The function obtained by the above method is used as the scale of operating tension for a given type of activity. It should be noted that the resolution of this scale depends on the degree of certainty of the obtained function. Degree of certainty refers to the correlation between the full range of changes in the measured parameters caused by change in problem difficulty and random (including those determined by individual distinctions) variations of the same parameters, that are unrelated to the work load. In some cases, it is expedient to construct the scale and use it on a rather homogeneous group of operators to increase its conclusiveness ["definiteness"].

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PSYCHOLOGY

PSYCHOLOGICAL SCIENCE IN SOCIALIST COUNTRIES

Moscow PSIKHOLOGICHESKAYA NAUKA V SOTSIALISTICHESKIKH STRANAKH in Russian 1981 (signed to press 2 Apr 81) pp 2-4, 224

[Annotation, foreword and table of contents from book "Psychological Science in Socialist Countries," edited by USSR Academy of Sciences Corresponding Member B. F. Lomov, Institute of Psychology, USSR Academy of Sciences, Izdatel'stvo "Nauka", 4,300 copies, 224 pages]

[Text] This collection reflects the status and developmental trends of psychological science in socialist countries. It provides a theoretical analysis of psychological information accumulated as of today; it examines the basic directions of the development and application of psychological knowledge in the social practices of socialist countries.

The book is intended for a broad range of psychologists.

Contents

Foreword

Developed socialist society is witnessing significant growth in the role played by sciences studying the influence of the human factor in all spheres of life--in solving the problems associated with building the material-technical base of communism, with accelerating scientific-technical progress and increasing the effectiveness of production, with improving social relations and with shaping the new man. Among these sciences, psychology occupies an important place. The social practices of all socialist countries demand intensive development of psychological science. One of the prerequisites of successfully solving the pressing theoretical and practical psychological problems is to achieve collaboration among psychologists of socialist countries. This collaboration presupposes cooperative effort in solving this problem and a certain degree of division of labor.

The scientific ties between psychologists of socialist countries have been developing intensively in recent years: Bilateral and multilateral agreements are being signed to permit joint solution of a number of problems in different branches of psychological science, exchange of information in different forms and discussion of pressing problems at conferences and symposiums. New forms of collaboration among psychologists of socialist countries have arisen--the First Conference of Psychologists of Socialist Countries was held in Potsdam (GDR) in 1978. A decision was made to hold such conferences systematically in different countries. The first conference of directors of psychological institutions in socialist countries was held in Moscow in 1976. In 1979 a conference of the directors of psychological institutes was held in Poland. The status, tasks and prospects for development of psychological science in socialist countries were discussed at the Moscow conference. Recommendations to publish the proceedings of this conference were approved. The book offered here for the reader's inspection consists of articles prepared basically from reports given at the conference by executives from psychological institutions, prominent scientists and the leaders of the psychological societies of Bulgaria, Hungary, Vietnam, the GDR, Cuba, Poland, Romania, the USSR and Czechoslovakia.

The development of psychological science in socialist countries shows that this process is following certain common laws. Marxist-Leninist theory is the common foundation for the study of psychology in different socialist countries.

The unique features behind the sociohistoric development of socialist countries and the internal logic of the development of psychological science in these countries went a long way to predetermine the level of development of this science, its directions and the problems it studies in different countries. The main trends in the development of psychology include a convergence of the leading psychological schools and directions in terms of their approaches, principles, methods, statements of goals and choice of the means of attaining them. These general

methodological principles are: development of consciousness on a sociohistoric basis, determinism, unity of consciousness and activity, the principle of reflection and the systems approach.

The book distinguishes two basic directions in psychological science--development of the fundamental problems, and development of applied studies having direct practical significance. In the opinion of the book's authors, success in these two directions requires that we study the basic methodological and theoretical premises of Marxism-Leninism, and that we successively criticize and deeply analyze various directions of bourgeois psychological science.

In their practical aspects, psychological studies are oriented on the following problems: particular features of the socialist way of life, formation and development of the personality, psychological problems associated with raising the effectiveness of ideological indoctrination and improving social control, the psychological aspects of raising labor productivity, and particular features in human activity and behavior in the face of scientific-technical progress.

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GENERAL PRINCIPLES OF PSYCHOLOGY

Moscow OBSHCHAYA PSIKHOLOGIYA in Russian 1981 (signed to press 16 Jan 81) pp 2, 382-383

[Annotation and table of contents from book "General Psychology", edited by V. V. Bogoslovskiy, A. G. Kovalev and A. A. Stepanov, 3d edition, revised and supplemented, approved by the USSR Ministry of Education as a textbook for students of pedagogical institutes, Izdatel'stvo "Prosveshcheniye", 279,000 copies, 384 pages]

[Text] This textbook was prepared by the collective of the department of psychology of the Leningrad Order of the Red Labor Banner State Pedagogical Institute imeni A. I. Gertsen. Department chairman--Prof A. I. Shcherbakov.

The following participated in the writing of this textbook:

V. V. Bogoslovskiy--Chapter 6 "Personality and Collective", Chapter 7 "Psychology of Communication and Interpersonal Relationships" (§1 jointly with A. A. Stepanov), Chapter 15 "Imagination and Creativity" (except for §4), Chapter 17 "Volition and Volitional Properties of the Personality", A. D. Vinogradova--Chapter 11 "Perception and Powers of Observation", §1 and 3, Chapter 16 "Emotions, Sentiments and Emotional Properties of the Personality"; A. G. Kovalev--Chapter 4 "Personality and Its Structure", Chapter 5 "Personality Orientation", Chapter 18 "Temperament", Chapter 19 "Character", Chapter 20 "Capabilities"; L. P. Mikhaylova--Chapter 3 "Development and Present Status of Psychology As a Science" (jointly with A. A. Stepanov); A. I. Rayev--Chapter 1 "The Object of Psychology" (jointly with A. I. Shcherbakov); Chapter 2 "Methods of Psychology" (jointly with L. A. Regush, Chapter 13 "Thinking and Intellectual Features of the Personality" (jointly with L. A. Regush); L. A. Regush--Chapter 2 "Methods of Psychology" (jointly with A. I. Rayev), Chapter 13 "Thinking and Intellectual Features of the Personality" (jointly with A. I. Rayev); A. A. Stepanov--Chapter 3 "Development and Present Status of Psychology As a Science" (jointly with L. P. Mikhaylova), Chapter 7 "Psychology of Communication and Interpersonal Relationships" (§1 jointly with V. V. Bogoslovskiy), Chapter 8 "Psychology of Activity", Chapter 9 "Attention and Attentiveness", Chapter 10 "Sensations and Sensory Organization of the Personality", Chapter 12 "Memory, Ideation and Mnemonic Properties of the Personality", Chapter 14 "Speech and Speech Properties of the Personality", §4 Chapter 15 "Imagination and Creativity"; S. N. Shabalin--Chapter 16, §2 and 4; A. I. Sherbakov--Chapter 1 "The Object of Psychology" (jointly with A. I. Rayev).

Contents

Part IV. Individual-Typological Features of the Personality

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PSYCHOSOMATIC CORRELATIONS IN CHRONIC EMOTIONAL STRESS

Novosibirsk PSIKHOSOMATICHESKIYE VZAIMOOTNOSHENIYA PRI KHRONICHESKOM EMOTSIONAL'NOM NAPRYAZHENII in Russian 1981 (signed to press 31 Aug 81) pp 2-8, 178

[Annotation, introduction and table of contents from book "Psychosomatic Correlations in the Presence of Chronic Emotional Tension", by Lev Yevgen'yevich Panin and Vladimir Petrovich Sokolov, Clinical Research Center of the Siberian Branch of the USSR Academy of Sciences and Institute of Clinical and Experimental Medicine, Siberian Branch of the USSR Academy of Medical Sciences, Izdatel'stvo "Nauka", 3100 copies, 179 pages]

[Text] This monograph deals with one of the pressing problems of modern biology and medicine--investigation of correlation between mental and emotional aspects of man, on the one hand, and function of autonomic and visceral systems of the body, on the other. The authors analyzed the nature of changes in these relations in the presence of chronic emotional stress [or tension]. The syndrome of psychoemotional stress was singled out. Its clinical, psychological, endocrinological and metabolic features are described. This problem is particularly important in view of intensive scientific and technological progress and effect of information stress on man. The link between emotional tension and development of cardiovascular pathology (atherosclerosis, ischemic heart disease, arterial hypertension) is discussed as it relates to the conditions of the Extreme North. This book is intended for physicians, biologists, biochemists, psychiatrists and psychologists. Tables 65, figures 20, references 225.

Introduction

The term, adaptation, refers to the complex process of the body's adjustment to adverse environmental conditions. It is expedient to make a distinction between two aspects of this phenomenon, dynamic and static. Adaptation of separate individuals, regardless of their position on the evolutionary ladder, corresponds to brief changes in the environment, lasting much less time than the life span of an individual. In this case, the term, adaptation, serves to designate the structural and functional alteration of the organism, and it is used as a dynamic concept. In the case of prolonged exposure to extreme stimuli, the organism changes to a new functional level as the result of function of adaptive mechanisms. In this case, adaptation is used to designate the state of the organism, i.e., as a static concept.

In the evolutionary aspect, adaptation is viewed from the standpoint of conformity of phenotypic and genotypic traits of an organism with the habitat. Hence the conception of ecological niche, in which this conformity is the fullest and most adequate. In this sense, adaptation is one of the main contents of the evolutionary process and is viewed as a static concept. When there are stable and prolonged changes in the environment, lasting substantially longer than the life span of a single individual, adaptation is discrete, and it is related to variability, heredity and natural selection, i.e., it is viewed as a directed [guided] process (dynamic concept). In this case, the concepts of "evolution" and "adaptogenesis" are identical.

Not only individuals, but populations (species) are formed as a result of natural selection. Physiological (individual) and population (species) mechanisms of adaptation work together as a single, purposeful biological mechanism.

Adaptation mechanisms gradually became more complex in the course of evolution of the animal kingdom. Their hierarchy was an organic blend of the principle of autonomy on the level of the cell, different functional systems with the principle of subordination and integration on the whole organism level (Vasilevskiy, 1978). In essence there are four stages of development and complication of adaptive mechanisms that correspond to the most important stages of evolution (formation of the most elementary forms of life, appearance of unicellular and primitive multicellular animals; complication of multicellular organisms and formation of the internal environment of the organism; appearance of the nervous system; formation of the second signal system and mind).

At the first stage of evolution, there were simple, stabilizing adaptation systems. They were based primarily on allosteric and isosteric mechanisms of regulation of enzyme activity, the action of close and distant feedback in metabolic pathways, presence of competitive correlations. The internal medium became the barrier that separated the organism from direct contact with the external environment, the characteristics of which change significantly depending on the time of day, season, etc. Unlike the external environment, the internal one (blood, lymph, tissue fluid) retains relative stability. Contact between each cell of a living organism with the endogenous environment, which retains relatively stable physicochemical characteristics, creates optimum conditions for all of its vital functions. "Constancy of the internal environment is the condition for free and independent life.... Stability of the environment implies such perfection of the organism that exogenous changes are immediately compensated and balanced" (Bernard, 1937, p 96). It is expressly with the endogenous environment that many homeostatic systems, upon which is based the organism's adaptive behavior, are connected.

However, the constancy of the internal environment is not absolute, it is relative. When the organism is exposed to extreme stimuli, it actively forms the internal environment that permits optimization of physiological processes under new living conditions. This is done by means of purposeful mechanisms, fixed through evolution, that determine the operation of homeostatic functional systems. The endogenous environment changes constantly in order to compensate

for the effects on the organism of altered living conditions, to assure survival in a new, unusual situation. Somatic changes are reflected primarily by change in the organism's internal environment.

When the existing organic world became more complex, it led to refinement of self-regulating systems. The need for a fine differentiated response, a more adequate and rapid one, to diverse effects of environmental factors led to formation of the nervous system. This meant a change to a basically different level of organization of adaptive processes, with directed transmission of flow of information, which became more economical and more accurate than before (Lyapunov, 1962; Kaznacheyev, 1973). Further complication of regulatory mechanisms led to formation of the central nervous system (brain) and appearance of such complex attributes of adaptive behavior as instinct, memory, emotions, etc. "The higher ... the sensory organization through which an animal is oriented in time and space, the broader the range of possible life encounters, the more diverse the environment that affects the organism and means of possible adaptations" (Sechenov, 1952, p 63).

Nervous mechanisms of regulation were not a simple addition to humoral ones; rather, they constituted a functional adjustment that qualitatively altered the operation of the latter. The idea that the nervous system plays a part in controlling adaptive acts was first advanced by I. M. Sechenov. He believed that the biological meaning of reflexes consists of being a means of communication between the organism and the world around it, living conditions and, which is the main point, of being a regulator of these communications, literally "the manager of actions consistent with these conditions (i.e., purposeful and adaptive actions)" (Sechenov, 1957, p 416). Subsequently, these ideas were developed by I. P. Pavlov in his doctrine of nervism.

With the appearance of man, new forms and mechanisms of adaptive behavior appeared, which were related to development of the second signal system, further development and refinement of the mind. They implied already elements of cognition of the environment: storage and transmission of information, learning, existence of interpersonal relations, participation in socially useful labor, capacity for creativity. Man's capacity for apperception and even forecasting development of future events and changes in the environment, what P. K. Anokhin (1975) called the principle of anticipatory reflection, is very important.

With the appearance of mental (psychophysiological) adaptation, the range of man's adaptive capabilities broadened considerably. This is related, first of all, to better understanding of the essence of processes occurring in nature and society. With the appearance of human society, numerous social forms of adaptive behavior appeared, among which man's transforming activity began to play a dominant role. Man not only retains adaptive functions inherent in him as a biological being, he also refines them by developing training systems, conditioning, engaging in physical culture and sports. However, man does not so much adapt to the environment as he transforms it in accordance with his needs and requirements. He develops protective equipment, creates an artificial microclimate and refines the system of social relations.

Development of social consciousness in the form of various social institutions, intensive scientific and technological progress of modern society opened up new opportunities to improve the relations between man and society, man and industry, man and the environment. The concept of "adaptive-adapting system" began to apply to human society (Petlenko, Tsaregorodtsev, Sakhno, 1976); it reflects the basic difference between human and animal adaptation mechanisms. The idea was advanced that, unlike other living beings who adapt to their habitat only biologically, by means of phenotypic and genotypic changes in the course of adaptogenesis controlled by natural selection, man, who remains unchanged in the genotypic, species-related respect, adapts socially to the environment by changing it (Frolov, 1975, quoted by Korolenko, 1978).

The mind is the most sophisticated and vulnerable system of man's adaptation to the social and ecological environment. When the body is exposed to extreme stimuli in the presence of acute and particularly chronic stress, this form of adaptation may be the first to be impaired. As a result of existence of psychosomatic relations, this leads to changes on lower levels of structural and functional organization, primarily of vegetovisceral systems (Kurtsin, 1973) and could lead to development of a systemic pathological process. Subsequently, its influence is rejected by the distinctions of the pathogenesis, which reflects the established, stable correlations in development of disturbances and lend a syndromal nature to the pathological process.

The nervous system has a direct influence, through nervous mediators and hormones, on the functional state of organs, cells and intracellular metabolism. Somatic changes are immediately reflected by a change in the body's internal environment. These changes may be brief and could be eliminated by the function of homeostatic mechanisms, or else they may be lengthy, when the organism changes to a new level of homeostasis. Thus, we were the first to show that at high latitudes, man develops a polar metabolic type under the influence of subextreme and extreme factors (Panin, 1979). The typical distinction of this type is a change in energy metabolism, from the carbohydrate to the lipid type (Panin, 1978). The influence of neural mechanisms on the endogenous environment is very complex on the level of higher nervous activity. Thus, the endogenous environment is an excellent indicator of the state of psychosomatic relations. Analysis of these relations is of enormous interest, not only to gain understanding of the entire complexity of man's adaptive behavior mechanisms, but to determine the pathogenesis of diseases that are usually classified as psychosomatic pathology: arterial hypertension, ischemic heart disease, peptic ulcer, neurotic states and many others. It is not by chance that scientific and technological progress, acceleration and urbanization of life led to a rise in expressly these diseases.

The change in psychosomatic relations is of considerable interest in the presence of chronic systemic tension, when favorable and rather prolonged conditions are created for development of a pathological process. However, amazingly expressly such states in man have been studied very little. We investigated the effects of subextreme and extreme environmental factors, the influence of urbanization factors on mental adaptation, metabolism, change in neuroendocrine and endocrine-metabolic relations in man. We studied the role of these changes in formation of cardiovascular pathology--ischemic heart disease and arterial hypertension.

The studies were conducted on four groups of men: 1) immigrants to northern Asia under conditions of an intensive urbanization process (Noril'sk, marked influence of ecological and urbanization factors); new arrivals to nonurbanized settlements in northern Asia (settlement of Dikson, predominant influence of ecological factors); 3) residents of an urbanized inhabited locality in the southern part of West Siberia (Novosibirsk, chiefly the influence of urbanization factors); 4) polar research workers at Soviet Antarctic stations (predominant influence of social and ecological discomfort factors).

Investigation of mental adaptation acquires particular importance in connection with the intensive exploration and industrial development of eastern and northern parts of our country, creation of enormous territorial-industrial complexes there, mining, appearance of cities and settlements. In these regions, a new industrial and social infrastructure is being formed. Implementation of these programs involves a strong influx of people from different parts of the country. The problem arises of man's adaptation to unusual climate and geographic conditions, unfamiliar situation and change in living stereotype. The effects of these factors are manifested first of all in man's neuropsychological status.

It is important to stress that the mechanisms of psychological adaptation differ from all other self-controlling and autonomous systems of the body in that there is conscious regulation, which is based on personality assessment. The latter is always perceived through emotions. Social and personality sets acquire much significance. According to I. S. Kandror (1968), psychological adaptation to the extreme conditions of the Extreme North is related primarily to deliberate and adequate assessment of the harsh climate and geographic conditions, as well as certain social and psychological deprivations, a rift from family and friends, restriction of range of customary activities, etc. Psychological adaptation also has elements of habituation to a monotonous environment, monotonous landscape and unusual photoperiodicity. All this requires a profound change in man's habits and inclinations.

According to our data, the emotional sphere is the first and most sensitive adaptive mechanism that mediates the effects of the set of extreme factors of the Extreme North on the organism. This monograph deals with investigation of expressly these mechanisms.

The authors express their profound appreciation to N. L. Bochkareva, G. T. Kovalevskaya, L. S. Ostanina, P. Ye. Vloshchinskiy, M. P. Moshkin, L. M. Polyakov and T. G. Filatova, who participated actively in gathering and processing the material used in this monograph.

Contents

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SOURCE AND GENESIS OF MENTAL IMAGE (GNOSIOLOGICAL ANALYSIS)

Kishinev OB ISTOCHNIKE I GENEZISE PSIKHICHESKOGO OBRAZA in Russian 1981 (signed to press 27 Nov 80) pp 2-8, 118

[Annotation, foreword and table of contents from book "Source and Genesis of Mental Image", by Anatoliy Panteleymonovich Saboshchuk, edited by M. V. Popovich, doctor of philosophy, Moldavian Academy of Sciences, Department of Philosophy and Law, Izdatel'stvo "Shtiintsa", 600 copies, 120 pages]

[Text] This book was reviewed and recommended for publication by A. I. Babiy and S. B. Krymskiy, doctors of philosophy.

The monograph develops the thesis of Marxist-Leninist reflection theory concerning substantive work as a source of perception and thinking. It provides logical and psychological validation to the fact that the informative link between an object and subject is mediated by exogenous and endogenous activity processes, which serve as the source of structural organization of a mental image. The most important result of this investigation is proof of the direct link, unmediated by senses, between thinking and the outside world, and the ensuing validation of the thesis that there are specific mechanisms, distinct from sense organs, that implement this direct association between thinking and objective reality. This book is intended for scientists, instructors and students of humanity faculties.

Foreword

A sharp ideological struggle is in progress between two main philosophical world outlooks with regard to the question of the nature of the psychological element, its place in the material world: between materialism and idealism. It is specifically stated as the problem of relationship of psychological to material processes occurring in a subject's internal and external worlds. "The major basic question in all philosophy, particularly the latest," wrote Englse, "is the question of relationship of thinking to everday life."[1] In essence it covers all of the problems of philosophical world outlooks. Along with traditional, ontological (which is primary, which is secondary) and gnosiological (can one learn to know the world), it contains psychophysiological, praxeological, personalistic, axeological and many other aspects. Each historical stage of development of philosophical thought considered far from all these aspects, and dissimilar attention was devoted to

each of them. Depending on the practical and scientific needs, attention was concentrated on some of them while others were shifted to the background. Only dialectical materialism--the highest form of development of dialectics and materialism--answers the main question of philosophy in a comprehensive manner, taking into consideration all its sides and aspects.

The source of mental images is one of the most important problems, namely, which exogenous and endogenous factors are associated with the contents of a subject's mental images (sensations, perceptions, conceptions, etc.). Idealism takes the psychological element out of the internal, self-contained spiritual world of a subject or absolute idea that precedes and generates objective reality. For materialism, "... the ideal is nothing other than the material transplanted into man's head and transformed in it."[2] Transformation of the material element into the ideal is a process of reflection. Tangible phenomena and processes serve as its base data, while the mental images that reflect them are the final results.

Of course, there is no need to dwell in detail on the importance and urgency of this problem to development of philosophy. Suffice it to mention, in this regard, that its scientific solution (we refer to the most general solution, since solution of such problems is an historic process that cannot be concluded at some stage of human cognition) undermines idealism and, at the same time, is one of the most important confirmations of the dialectical materialistic world outlook.

Representatives of pre-Marxist and non-Marxist materialism consider as the only source of the psychological factor the objects and phenomena in the material world that elicit, by affecting sense organs, perceptual or mental pictures of them in the subject's head--subjective images. Such interpretation can be expressed as the scheme of thing → image. It is characterized by a passive contemplative approach to interpretation of the reflection process, in which the mental image is viewed as the result of unilateral and direct effect of an object on the subject's organs of reflection. This approach presents a number of unsolvable difficulties. We shall discuss here three of them.

1. There are many phenomena, the origin of which cannot be attributed to objects, in mental reflection. In particular, they include perceptual and mental acts of constructing and transforming ideal images, which cannot be attributed to changes occurring in the objective world. Representatives of passive and contemplative materialism explained their occurrence on the basis of inborn physiological or mental capacities of the subject, which was in contradiction with the main premise of materialism: there is nothing in the mind that is not present in the material processes it reflects.

2. The subject does not perceive an object directly, instead he perceives the changes that it makes by affecting the subject's sense organs. Hence, an unsurmountable difficulty within the framework of metaphysical materialism: how does a mental image arise if an object affects unilaterally the subject's analyzer systems, and why do we attribute the subjective state of our mind to external objects as their objective features. Of course, one can again answer these questions within the limits of theoretical analysis expressed by the scheme of thing → image by again referring to congenital physiology

(physiological idealism) or the subject's mental (subjective idealism) capacity. Both answers lead to recognition of predetermined harmony, which is inherent in the teleological world outlook.

3. The passive and contemplative approach to the process of reflection was the main cause of absence in its representatives of a historical view of the nature of reflection organs, and this was manifested by overlooking the qualitative specifics of organs of human cognition, reducing them to sense organs, which were viewed as the sole receiver of information coming to the subject from the outside world. But thinking reflects mostly the qualitative and quantitative characteristics of objects that are inaccessible to the organs of perceptive reflection. Sensualism was one of the philosophical directions that tried to resolve the contradiction; its representatives proceeded from the premise that thinking is mediated, rather than direct, perception of reflection of material reality and that, consequently, perception is the only immediate source of thought. However, the numerous attempts to remove thinking from sensory elements failed to yield positive results, since perception did not have its own mechanisms capable of elevating it to the intelligence level. Consideration of perception as the only source of thinking and impossibility of removing thought, with all its specificity, from sensory elements constituted a contradiction that resulted in either denial of the qualitative specifics of reason, reducing it to senses, which is inherent in empiricism and positivism, or recognition of reason's innate or God-given capacity to directly comprehend the essence of things.

The common feature of all the above difficulties is that it is impossible to provide complete and comprehensive materialistic validation of the mental element on the basis of recognizing it as the only source of external objects. The presence of subjective elements in the psyche, the appearance of which cannot be explained within the limits of the passive-contemplative approach to the reflection process, has always led to retreating from materialism, and it constituted the gnosiological basis of subjectively idealistic trends, which always changed more or less systematically to objective idealism because of their solipsistic perspective. Kant--Fichte--Hegel constitute the typical line of development of all philosophical trends that use subjective phenomena as the basis, for which there is no materialistic validation at this stage of development of philosophy.

Marxist-Leninist classicists, who introduced into gnosiology the category of "material activity," which reflects interaction between object and subject oriented toward satisfying the needs of man or animals, outlined the basic solution to the problems related to the above-mentioned difficulties. V. I. Lenin stated: "The point of view of life, practice, should be the first and basic point of view of theory of knowledge. And it inevitably leads to materialism, rejecting the infinite contrivances of professorial scholastics."[3] Material [substantive] activity performs a number of functions in reflection. The most important one is that it serves as the source of mental reflection through its material interaction between object and subject.

Recognition of activity, practice as the main source of mental reflection is what distinguishes dialectical materialist gnosiology from all pre-Marxist

and non-Marxist epistemological conceptions. K. Marx indicated: "The chief flaw of all prior materialism, including Feuerbachian materialism, is that the object, reality, sensuality is taken only in the form of an object or in the form of contemplation, but not as man's sensual activity, experience [practice], not subjectively. This is why it happened that the active aspect, as opposed to materialism, was developed by idealism, but only abstractly, since idealism, of course, does not know of real, sensual activity as such."[4]

Marxist-Leninist classicists found a common basic approach to solving the problems that metaphysical materialism encountered because of its passively contemplative nature. This approach was defined and further developed in the works of Soviet and foreign Marxist philosophers.[5] However, the above-mentioned difficulties, particularly the last two, never were defined by theory of knowledge of dialectical materialism and thus, in our opinion, are attributable to underestimation of the role of material activity as the source of mental images.

For example, the opinion is held widely, with reference to solving the problem of genesis of the perceptual image in both gnosiology and psychology, that the mental image owes its origin entirely to the exogenous effects of objects on receptor systems, which presumably have the capacity to receive and project exogenous information going to the brain. Thus, one of the proponents of this view, L. M. Vekker, believes that "the initial mental structures are determined in their original volume and composition by an object, whereas action, which is a mandatory prerequisite for further structuring of information, is still of a derivative nature in relation to this initial determination. It builds the informational structure, but is not the base material for building it. It involves expressly operator, but not operand, composition of information."[6] However, this does not eliminate the difficulty of explaining the genesis of a mental image, but is transported from the entire class of images to the part of it that consists of initial mental structures.

It was also found impossible to derive thought with all its specificity from sensory data. Most researchers concerned with the problem of correlation between senses and reason believe that perceptual reflection is the only source of thinking. In one of the recent works dealing with the source and genesis of thinking, it is noted "that active [lively] contemplation of reality, its reflection in sensations, including kinesthetic sensations, was and remains the only source of our knowledge."[7] In the opinion of authors who share sensualistic sets, the contradiction between perception and thinking is overcome through experience. The latter is correct but only provided thinking is the direct reflection of objects in practical activity that are inaccessible to sensory perception. But this is incompatible with the thesis of sensualism that mental reflection of reality is mediated by the senses.

The difficulties we have mentioned are already an indication of the small amount of work done on the general philosophical problems of the source, genesis and mechanisms of mental reflection. This is recognized also by specialists in the field of gnosiology and psychology of cognitive processes. V. S. Tyukhtin writes: "In general, solution of the problem of the nature of the sensory

image is presently at the stage of plausible hypotheses."[8] The same can be stated about cognitive mental images. Thus, L. I. Antsyferova observes: "Nongraphic knowledge, construed as abstract thought, is formed only on the basis of the sensory level of cognition. But this thesis does very little to advance the difficult problem that has yet to be solved (underlined by A. S.) of the substantive content of abstract categories of thinking. At the present time, the problem can merely be formulated as follows: specifically how is abstract knowledge related to its sensory roots."[9]

In our opinion, one can offer the correct explanation of genesis of mental images only by relating it to definition of the Marxist thesis of material activity as the source of mental activity. First of all, we must clarify the meaning of the statement made by Marx to the effect that an object must indeed be taken in the form of material experience--subjectively. In our opinion, this means: 1) reflection, transplantation of the material into man's head and transformation thereof into the ideal is never direct and immediate; 2) the thing → image relationship is always mediated by exogenous and endogenous activity processes which, in addition to their immediate function--to serve as a means of fulfilling vital needs--perform a reflective function: they carry information from object to subject. Proceeding from this definition and on the basis of data referable mainly to modern pyschological research, the author undertakes the task of finding the main elements involved in the informational connection between the object and mental image that constitute as a whole the general mechanism of the internal ideal plan of reflection. Performance of this task is limited to the narrow range of mental images that includes perception and elementary, meaningful, abstract concepts.

FOOTNOTES

1. Marx, K. and Engels, F., "Works," Vol 21, p 282.

2. Ibid, Vol 23, p 21.

3. Lenin, V. I., "Complete Works," Vol 18, p 145.

4. Marx, K. and Engels, F., "Works," Vol 3, p 1.

5. Yaroshevskiy, Tadeush M., "Thoughts About Experience," Moscow, 1976;
Pavlov, T., "Reflection Theory," Moscow, 1936;
Yakushevskiy, I. G., "The Problem of Subject and Object in Classical and Modern Bourgeois Philosophy," Moscow, 1965;
Leont'yev, A. N., "Problems of Mental Development," Moscow, 1965;
Spirkin, A. G., "The Origin of Consciousness," Moscow, 1960;
Idem, "Activity, Consciousness and the Personality," Moscow, 1975, and others.

6. Vekker, L. M., "Mental Processes," Leningrad, Vol 1, 1974, p 311.

7. Panov, V. G., "The Sensual, Rational and Experience," Moscow, 1975, p 135.

8. Tyukhtin, V. S. "Image," "Philosophical Encyclopedia," Moscow, Vol 4, 1967, p 111.

9. Antsyferova, L. I., "Introspective Experiments and Studies of Thinking in the Wurzburg School," in "Osnovnyye napravleniya issledovaniy psikhologii myshleniya v kapitalisticheskikh stranakh" [Main Directions of Research on Psychology of Thinking in Capitalistic Countries], Moscow, 1966, p 73.

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